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NOTES ON THE STRUCTURE OF THE EMBRYO-SAC IN SPARGANIUM AND LYSICHITON.

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(WITH PLATE I)

RECENT studies on the structure of the embryo-sac of the angiosperms have made it very evident that more variation exists than was formerly supposed. All forms as yet examined agree in the essential characters of the earlier stages of the embryo-sac, but its later stages show much variation, especially in the character and behavior of the antipodal cells. Other marked deviations from the type structure have been recorded, but as yet these are too few and fragmentary to be of much value in interpreting the homologies of the structures of the embryo-sac. These discoveries, however, render it important that a careful study be made of the simpler types of angiosperms, as it is becoming more and more evident that it is among these that the primitive types are to be sought, and here, if anywhere, the clues to the origin of the angiosperms are likely to be discovered.

The writer has been for some time engaged upon a study of the simpler monocotyledons in the hope of being able to throw some light upon their affinities, which at present are very far from being clearly understood. Especial attention has been given to the study of the embryo-sac and embryo. Some of the

results of these studies have already been published,[1] and the present paper is a record of some of the more striking facts, especially in regard to the antipodal cells, brought to light in more recent investigations. It is hoped that it will soon be possible to give a fuller account of these points, as well as a study of the development of the embryo in the forms under consideration.

There is a growing tendency to regard the simpler monocotyledons, *i. e.*, those having either no floral envelopes, or inconspicuous ones, as the more primitive types, instead of assuming, as was formerly done, that they are degenerate forms descended from petaloideous ancestors. The present view is clearly expressed in the arrangement of the orders of monocotyledons in Engler and Prantl's *Natürliche Pflanzenfamilien*.[2] Engler's conclusions are drawn mainly from a study of the flowers, and as yet but little has been done, at least of late years, in the study of the development of these presumably primitive types.

During the past two years I have made somewhat extensive collections of material for these investigations, but as yet only a small part of the material has been worked over, and the results here given are only preliminary to what is hoped will be much more complete, studies which may perhaps help to clear up some of the questions as to the affinities of the lower angiosperms.

SPARGANIUM.

The genus Sparganium is a small one, probably comprising not more than ten species, mostly inhabitants of northern regions, but with representatives in New Zealand and Australia. Sparganium is usually included with Typha in the order Typhaceæ, but Engler has separated it as the type of a special order, Sparganiaceæ, with the Pandanaceæ as its nearest relatives.

Some years ago, I had occasion to examine the structure of

[1] CAMPBELL, A morphological study of Naias and Zannichellia. Proc. Cal. Academy of Sciences III. Bot. **1**: 1–61. 1897.

Development of Lilæa. Annals of Botany **12**: 1–28. Mr. 1898.

[2] Die natürlichen Pflanzenfamilien II. **1**: 183 ff. 1889.

the ovule in *S. eurycarpum* Engelm. and was struck with certain peculiarities which it exhibited, some of which were referred to and figured in my paper on Naias and Zannichellia. Most noticeable was the unusual development of the antipodal cells.

The study of Sparganium was interrupted for various reasons, but in the meantime material of other species was collected and the subject taken up again. During the past summer a good supply of *S. simplex* Huds. was obtained from Tallac, on Lake Tahoe, and through the kindness of Miss Alice Eastwood, a quantity of the Californian species, *S. Greenii* Morong, collected at Lake Merced near San Francisco, was sent me. I had also a small amount of a Japanese species, *S. longifolium* Turcz., collected by me at Akkeshi on the island of Yezo. Of these, *S. simplex* proved the most satisfactory for study and these preliminary notes refer principally to that species.

All the species of Sparganium are monœcious, the heads of pistillate flowers being at the base of the inflorescence. There are usually three or four of these pistillate heads in *S. simplex*. Each pistillate flower in this species consists of a single carpel, containing a solitary ovule, and surrounded by a number of membranaceous floral leaves. In *S. eurycarpum* and *S. Greenii*, the pistil is composed of two carpels.

In making sections of the carpels for the study of the embryo-sac, except in the youngest stages, care must be taken to remove enough of the hard outer tissues to permit the penetration of the fixing and embedding agents. Of the various fixing agents employed, the best results were obtained from the use of saturated solutions of corrosive sublimate or picric acid in alcohol. The chromic acid mixtures proved less satisfactory. A double stain of Bismarck-brown and anilin-safranin gave the best results.

All of my material was too old to make it possible to study the origin of the ovule and the early history of the embryo-sac. The development of the flowers has been studied by Dietz,[3] and from his figures it looks as if in Sparganium, as in most of

[3] Bibliotheca Botanica 5 : —. 1887.

the simpler monocotyledons hitherto investigated, the ovule is axial in origin.

The early history of the embryo-sac could not be traced, but as the mature sac, at the time of fertilization, corresponds closely with that of the typical angiosperms it is not likely that there are any marked peculiarities in its early development.

In the mature ovule (*figs. 1, 2*) the broad apex of the embryo-sac is covered by two layers of cells, the outer ones being elongated so that the apex of the nucellus is pointed. The cytoplasm is confined to an extremely thin layer lining the wall, and a small amount surrounding the polar nuclei. The egg-apparatus is relatively small but offers no especial peculiarities. The synergidæ (*fig. 2, s*) are smaller than the egg (*o*), and their cytoplasm is densely granular, whereas the egg appears almost transparent. The nuclei of the synergidæ are small, but distinct, and like that of the egg, they possess a conspicuous nucleolus. The nucleus of the egg is somewhat larger than the nuclei of the synergidæ, but otherwise resembles them.

On examining the antipodal region of the embryo-sac (*fig. 3*) the very small size of the antipodal cells (*ant*) is at once noticeable; indeed, where these have collapsed in the process of embedding, it is almost impossible to see them at all.

The polar nuclei are much larger than the other nuclei of the embryo-sac, and probably always fuse before fertilization is effected. This, however, has not been positively shown. In the specimen shown in *fig. 3*, the fusion of the polar nuclei was complete, and the single large endosperm-nucleus (*en*) was very conspicuous. In the embryo-sac of *S. Greenii*, however (shown in *fig. 4*), the two polar nuclei were clearly distinguishable, although they were in close contact.

The actual fertilization has not yet been observed, and owing to the small size of the nuclei of the pollen-spore and pollen-tube, it is not likely that this will be easy to demonstrate satisfactorily.

As usual, the synergidæ disappear after fertilization, and the egg-cell, now become the one-celled embryo (*fig. 6, em*), can

alone be distinguished at the upper end of the embryo-sac. There is little change in the embryo for some time, and it remains undivided until after there is a considerable development of the antipodal cells and endosperm.

An examination of the antipodal region of the recently fertilized embryo-sac (*fig. 7*) reveals a remarkable change in the antipodal cells, which seem to be immediately affected by the act of fertilization. While the embryo-sac itself has not increased appreciably in size, the antipodal cells have now enlarged to several times their original dimensions and present all the appearances of actively growing cells. The nuclei have divided, and in the specimen figured there were already present eight antipodal nuclei. It was difficult to decide whether in all cases the division of the nucleus was accompanied by the formation of a division wall, or whether, as in some other cases of multiplication of the antipodal nuclei, the division of the nucleus occurs without the formation of a cell wall.

The first division of the endosperm-nucleus takes place at about the same time that the first nuclear-division occurs in the antipodal cells. The secondary endosperm-nuclei arrange themselves, in the usual way, in the thin layer of protoplasm lining the wall of the embryo-sac, which now rapidly increases in size. Before any cell-division takes place in the endosperm, the antipodal cells have increased enormously in size, and have divided until they form a conspicuous hemispherical cell-mass projecting into the large lumen of the embryo-sac (*fig. 8*). The number is very great, more than a hundred, or in some older stages a hundred and fifty, thus exceeding, so far as I know, those of any other plants yet investigated. Each cell is clearly defined and is plainly uninucleate. The cytoplasm is very finely granular. The antipodals at this stage recall strongly those of certain Gramineæ.[4] It is very clear that we have to do here, not with a rudimentary structure, but with one which is undoubtedly of physiological importance. The endosperm at this stage is

[4] WESTERMAIER, Zur Embryologie der Phanerogamen, etc. Nova Acta d. kaiserl. Leop. Carol. Akad. der Naturf. **57**: 1–30. 1890.

scarcely at all developed, and here also, as Westermaier has pointed out in Zea and other grasses, this group of antipodal cells functions as the endosperm in the early stages of development after fertilization.

The nuclei in the antipodal cells of Sparganium never show any indications of fragmentation, such as has been described for the large antipodal cells of some Ranunculaceæ,[5] but they remain sharply defined, and the large nucleolus persists unchanged so far as has yet been observed.

Later there is the usual formation of cell-walls between the endosperm-nuclei, and the development of the endosperm proceeds centripetally. In the oldest stages examined (*fig. 9*), the large mass of antipodals was still evident, although there were some indications of breaking down in these cells. Whether traces of them can be detected in the ripe seed remains to be seen.

The development of the embryo of Sparganium has been already followed in *S. ramosum* Huds. by Hegelmaier,[6] but he gives no account of the embryo-sac. My own studies on the embryo are still too incomplete to make a comparison with the results of Hegelmaier possible. The embryo has the suspensor only slightly developed and there are a number of suggestive resemblances to the embryo of the grasses, which, in connection with the strong similarity in the embryo-sac, point to a possible connection between the Sparganiaceæ and Gramineæ.

As already indicated, it is among the Gramineæ that we find the type of embryo-sac which resembles most that of Sparganium. Hofmeister[7] was the first to call attention to the conspicuous antipodal cells in certain Gramineæ, and showed that the number might exceed the three usually found in angiosperms. Among the Triticeæ he found the number to be from six to twelve.

[5] MOTTIER, Contributions to the embryology of Ranunculaceæ. BOT. GAZ. **20**: 241, 248, 276, 304. 1895.

[6] Zur Entwickelungsgeschichte monocotyledoner Keime. Bot. Zeit. **32**: 631. 1874.

[7] Embryobildung der Phanerogamen, II. Monocotyledonen. Abhandl. d. königl. sächs. Gesell. d. Wiss. **7**: —. 1861.

The later work of Westermaier,[8] Fischer[9] and Koernicke,[10] has confirmed the results of Hofmeister's investigations and added a good deal to them. Of these investigators, Koernicke alone gives definite information as to the number of antipodal cells which may occur. According to his statements, the number may rise to thirty-six or even more, the largest number, so far as I know, yet recorded, but, as we have seen, very much smaller than the normal number in the older embryo-sac of *Sparganium simplex*. The most noticeable difference, aside from the number of the antipodal cells, is the very inconspicuous character of these before fertilization in Sparganium when compared with the antipodal cells of the Gramineæ.

Lysichiton.

Lysichiton Kamtschatcense (L.) Schott is a monotypic aroid of northeastern Asia and Pacific North America where it extends from Alaska to northern California. In general appearance it is much like the eastern skunk-cabbage, and it is locally known by the same name. Its inflorescence, however, is quite different and recalls that of some species of Anthurium; indeed, the whole plant resembles some of the larger species of this tropical American genus.

I am indebted to Professor Hill of the University of Washington for material of the young flowers and fruit, which he kindly sent me from Seattle. Material of the older stages was collected by me in the neighborhood of Sitka, where the plant grows in great abundance.

The Araceæ have been somewhat neglected in the numerous embryological studies that have been made upon the angiosperms, and, aside from Hofmeister's researches, there is very little work upon the development of the embryo-sac. Fischer[11]

[8] Westermaier, *loc. cit.*

[9] Fischer, A., Zur Kenntniss d. Embryosacentwickelung einiger Angiospermen. Jenaische Zeitschrift **14**:—. 1880.

[10] Koernicke, Verhandl. d. naturhistor. Vereins d. Preuss. Rheinlande, etc. **53**: 149. 1896.

[11] Fischer, *loc. cit.*

gives some account of the development of the ovule and embryo-sac in Arum, and Mottier has investigated the same points in Arisæma,[12] but beyond these I have not been able to find any references to the embryo-sac in this very characteristic group of plants. As the work of Hofmeister had already shown that the Araceæ exhibit certain marked peculiarities of the embryo-sac, it is remarkable that these plants have been overlooked in the more recent studies of the embryo-sac. The Araceæ give many indications of being a primitive and generalized order, and no group of angiosperms is likely to furnish more important data as to the origin of the structures of the embryo-sac.

In addition to the study of Lysichiton, the more important results of which are here given, more or less extensive studies have been made upon a number of tropical aroids, but these are not yet completed. The forms examined included species of Anthurium, Philodendron, and Dieffenbachia, collected in Jamaica during the summer of 1897.

The ovule of Lysichiton is very large (*fig. 10*) and characterized by the massive basal part, which is extraordinarily large when compared with the nucellus. In the younger ovule the outer integument is only slightly developed, but later it grows out beyond the inner one (*fig. 15*). The embryo-sac is deep-seated. So far as its early development has been followed, it does not differ from that of the typical angiosperms, and there are found the usual structures of the mature embryo-sac, *i. e.*, the egg-apparatus, polar nuclei, and three antipodal cells. While the embryo-sac itself is decidedly smaller than in Sparganium, the egg-apparatus and antipodals are much larger.

At first the nuclei of the cells of the egg-apparatus and the antipodal cells are much alike (*fig. 11*), but at the time of fertilization (*figs. 12, 14*) the antipodal nuclei have increased remarkably in size, while there has been little change in those of the egg-apparatus, although both the egg-cell and synergidæ

[12] MOTTIER, On the development of the embryo-sac in Arisæma triphyllum. BOT. GAZ. 17: 258. 1892.

have increased in volume. As in Sparganium, the latter are much more granular than the egg-cell, but there is less difference in size than is the case in Sparganium.

In the specimen which is shown in *fig. 14*, which was probably ready for fertilization, the two polar nuclei were still separate, but whether they fuse before fertilization is effected must remain for the present undecided.

The subsequent history of the embryo-sac in Lysichiton differs strikingly from that of Sparganium. There is a formation of free nuclei resulting from the division of the primary endo sperm-nucleus, but this is early followed by the formation of division-walls which extend entirely across the lumen of the embryo-sac, and this soon becomes completely filled with the large-celled endospermal tissue (*figs. 15, 16*). This filling of the embryo-sac with a continuous tissue seems to be characteristic of most of the aroids hitherto examined, and recalls the structure of the prothallial tissue in Selaginella or Isoëtes. The same type of endosperm has also been observed in various dicotyledons.

In Lysichiton, as in Sparganium, there is a marked growth of the antipodal cells subsequent to fertilization. They enlarge rapidly and divide, but the number is never large (the specimen figured showed eight). The cytoplasm of the antipodal cells is finely granular, and they are doubtless of physiological importance. Sometimes, as in the case figured (*fig. 17*), the antipodals are clearly separated from the basal endosperm cells which are much smaller; but this is not always the case.

The nuclei of the older antipodal cells become very large, and the conspicuous nucleolus of the younger nucleus becomes much less evident. The actual division of these nuclei was not seen, but the appearance of the chromatin in the cells shown in *figs. 12* and *13* indicates that they are preparing for division. The nuclei finally reach an extraordinarily large size, and far exceed those of the endosperm-cells. They are probably finally disorganized, but their further history was not followed. Whether fragmentation occurs, as in the large multinucleate antipodal cells of some

Ranunculaceæ[13] is doubtful, but there is little question that the early divisions are karyokinetic, and each division is followed by the formation of a division-wall.

The upper endosperm cells are usually decidedly larger than those which are in contact with the antipodal cells, but otherwise there is no marked difference between them.

As in the other aroids that have been studied, the upper part of the nucellus persists as a sort of cap covering the apex of the embryo-sac; the lateral tissue of the nucellus, however, is completely disorganized, so that the embryo-sac comes in close contact with the inner integument (*figs. 15, 18*).

So far as my observations go, the species of Philodendron, Anthurium, and Dieffenbachia examined agree closely with Lysichiton in the development of the embryo-sac, but as yet the presence of such conspicuous antipodal cells has not been observed. In many cases noted (see *fig. 18*) the embryo-sac, at a very early period, becomes completely filled with large-celled parenchyma, in which it is impossible to recognize any antipodal cells, nor in many cases can any certain traces of an embryo be detected. It is hoped that a more thorough study of these puzzling forms, which I expect to make soon, will explain the meaning of these appearances.

Except in Pistia, which has been carefully studied by Hegelmaier,[14] I have been unable to find any complete account of the development of the embryo among the Araceæ. Hofmeister gives figures of a few stages of a number of genera, but these are too incomplete to be of much value. A preliminary examination of the embryo of Lysichiton indicates that it is of much the same type as that of Pistia. Probably no suspensor is developed, and the young embryo is very soon completely imbedded in the endosperm, recalling the appearance of the embryo in Isoëtes (*fig. 16*).

The embryo finally completely fills the ripe seed, as it does in many other genera, *e. g.*, Anthurium, but in some of the aroids,

[13] MOTTIER, *loc. cit.*

[14] HEGELMAIER, *loc. cit.*

e. g., Philodendron, the embryo is smaller and surrounded by abundant endosperm.

SUMMARY AND CONCLUSIONS.

In both Sparganium and Lysichiton there is a normal multiplication of the original three antipodal cells, although the type of these cells is quite different in the two genera. In Sparganium, at least in *S. simplex*, the number of antipodal cells becomes very great, in extreme cases 150 or more, thus far exceeding that of any other known plant. The nearest approach to this is found in certain Gramineæ, where the form of the antipodal cells may be also much like those of Sparganium.

This extraordinary development of the antipodal cells in Sparganium, however, is secondary, and dependent apparently upon the fertilization of the egg-cell. In the unfertilized embryo-sac, the antipodals are unusually small and inconspicuous, and of the usual number. There is no evidence that the nuclei of the antipodal cells divide otherwise than by karyokinesis.

In Lysichiton the antipodal cells probably never exceed ten, but they become extremely large and the nuclei reach enormous proportions. Here, also, no direct division of the nucleus could be detected, but indications of degeneration were observed in the older nuclei, and it is possible that there may be, finally, a fragmentation like that found in the multinucleate antipodal cells of other plants. The character of the antipodal cells in Lysichiton is quite different from those of Sparganium, and, indeed, from those of any other described angiosperms. They resemble most, perhaps, such Compositæ as Senecio and Aster, in which there have been described numerous antipodal cells and a continuous endosperm. In these composites there may be also a multiplication of the nuclei of the individual antipodal cells.

It is evident that we can no longer regard the antipodal cells as merely vestiges of the primitive prothallial tissue. It is true that they probably represent this tissue, but that they may still be of importance physiologically is amply shown both by their

great development in the types under consideration, and by researches bearing upon their relation to the nutrition of the structures in the embryo-sac.[15]

Whether the striking resemblances in structure between the antipodal cells of Sparganium and those of certain grasses indicate any direct relationship between the Sparganiaceæ and Gramineæ, remains to be seen; but in connection with the undoubted similarities in the structure of the embryo, it is by no means improbable that these two supposedly isolated orders of the monocotyledons may really prove to be related.

That two such widely separated orders as Araceæ and Compositæ should show analogies in those structures which may very properly be assumed to be of importance as indicating relationships, seems very surprising. It must be remembered, however, that the Compositæ seem to have retained a very primitive type of ovule, *i. e.*, the solitary terminal ovule such as appears to be the most primitive type known in the angiosperms. This same type also occurs in many aroids, and is found again in the simpler Centrospermæ among the dicotyledons, *e. g.*, Polygonaceæ. In the Piperineæ, which show a number of curious analogies with the Araceæ, the same solitary axial ovule occurs. It is not impossible that a further study of Piperineæ may show that in them we have a point of contact between monocotyledons and dicotyledons. If it should be shown that the single ovule of the Compositæ is a primitive rather than a secondary condition, the occurrence of what seems to be a primitive type of embryo-sac in these most specialized of all angiosperms would be comprehensible.

Of course with our present very meager knowledge both of the simpler types of dicotyledons and of the aroids, any positive assertions as to the possible relationships of these groups are out of the question. That these groups deserve more careful study than has yet been given them, admits of little question.

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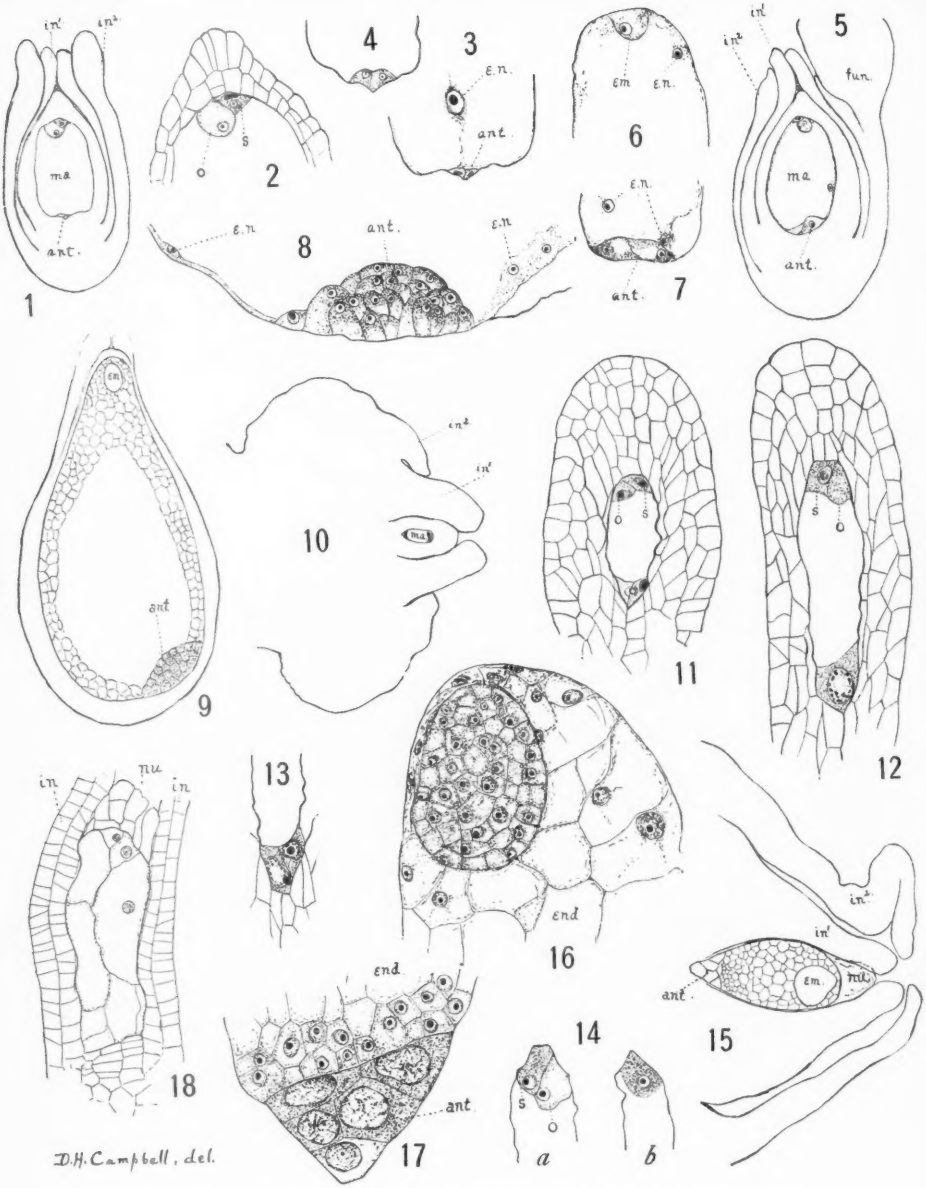
[15] See especially Westermaier's paper already referred to.



CAMPBELL on EMBRYO-SAC of SPARGANIUM and LYSICHITON.

EXPLANATION OF PLATE I.

All of the figures were drawn with a Zeiss camera — *Figs. 1, 5*, Leitz; obj. 3, oc. 3; *figs. 9, 10, 15;* Leitz obj. 13, oc. 1; the other figures, Leitz obj. 7, oc. 1. *Figs. 1–3, 5–9*, refer to *Sparganium simplex*; *fig. 4*, to *S. Greenii*; *figs. 10–17*, to *Lysichiton Kamtschatcense*; *fig. 18*, to *Anthurium cordifolium* Kth.

FIG. 1. Section through the mature ovule of *Sparganium simplex*; *in*^{1}, *in*^{2}, the integuments; *ma*, the embryo-sac.

FIG. 2. Upper part of the nucellus and embryo-sac, showing the egg-apparatus; *o*, the egg; *s*, one of the synergidæ.

FIG. 3. Basal part of the embryo-sac shown in *fig. 2*; *ant*, antipodal cells; *en*, endosperm nucleus.

FIG. 4. Antipodal cells of *S. Greenii*.

FIG. 5. Longitudinal section of a recently fertilized ovule; the section is cut at right angles to the one in *fig. 1*, so that the funiculus, *fun*, is shown.

FIG. 6. Upper part of embryo-sac, with one-celled embryo, *em*, and one of the secondary endosperm-nuclei, *en*.

FIG. 7. Antipodal region of the same embryo-sac showing two of the enlarged antipodals and two endosperm-nuclei, *en*.

FIG. 8. Antipodal region of an older embryo-sac, showing the large mass of antipodal cells, and the thin parietal layer of protoplasm with the included endosperm nuclei.

FIG. 9. Longitudinal section of an older ovule, showing the embryo-sac lined with a layer of endosperm, in the upper part of which is embedded the embryo, *em*.

FIG. 10. Longitudinal section of a young ovule of Lysichiton.

FIG. 11. The nucellus of the same more highly magnified. The egg, *o*, and one of the synergidæ, *s*, show at the apex, and two antipodals at the base of the embryo-sac.

FIG. 12. Longitudinal section of a nearly mature nucellus; one antipodal cell only can be seen.

FIG. 13. The two other antipodal cells from the embryo-sac shown in *fig. 12*.

FIG. 14. Two sections through the apex of a mature embryo-sac of Lysichiton; in *a* the egg and one synergid show, the second synergid shown in *b*.

FIG. 15. Longitudinal section of an older ovule with the embryo, *em*, sur-

rounded by a mass of endosperm; the embryo-sac has destroyed all of the nucellus except its apex, *nu*; *ant*, the antipodals.

FIG. 16. Upper part of an embryo-sac and embryo, of the same age as the one shown in *fig. 15*.

FIG. 17. The antipodal region of the same embryo-sac, showing the marked difference between the antipodal (*ant*) and endospermal (*en*) cells.

FIG. 18. Longitudinal section of the embryo-sac of *Anthurium cordifolium*; *nu*, the remains of the nucellus; in the inner integument neither antipodal cells nor embryo can be distinguished.

THE ECOLOGICAL RELATIONS OF THE VEGETATION ON THE SAND DUNES OF LAKE MICHIGAN.

HENRY CHANDLER COWLES.

[*Continued from p. 117.*]

3. The upper beach.

In the strictest sense the upper beach is not a portion of the beach at all, since it is beyond the reach of the waves; it might perhaps be called a fossil beach, but the fact that it is continuous with the beach proper seems to exclude that term, as does the recency of its fossilization. The expression fossil beach will be reserved for a formation of greater geological age and separated from the present beach by other topographic forms. Where dunes are superposed upon the beach, the upper limits of this third beach zone are quite vague, though the theoretical line of demarcation is where the sand is first accumulated by the wind. Where clay bluffs are present at the water's edge, the beach is quite narrow and the upper limit fairly well defined, though at times obscured by alluvial fans. Occasionally the upper beach approaches very close to the water's edge; this is the case where the lower and middle beaches are very narrow because of a high gradient. Sometimes the lower or middle beach zone is replaced by a tiny cliff; in such a case the upper beach may approach to the edge of this cliff. The limits of the upper beach, as of other beach zones, are constantly shifting. The lower limits are carried lakeward or landward by the waves of winter storms, but on the whole the lower limits are pushed out more and more lakeward, keeping pace with the advance of the lower beach. The shifting of the wind causes variations in the upper limits, but on the whole the dunes likewise are commonly formed more and more lakeward, as will be shown further on. The three beaches, then, shift from year to year with apparent irregularity, but there appears to be as a resultant a general pro-

gressive movement of them all out into the lake. As a whole the three beach zones slope gradually and somewhat evenly upward, toward the dunes or bluffs beyond; depressions, however, are not at all uncommon, and at times they reach down to the water level, so that a beach pool results.

The life conditions are much less severe than on the middle beach, and chiefly because of the freedom from the wave action of the winter storms. The exposure to the sun is almost as great as on the lower zones, but there is more protection from the wind because of the abundance of driftwood. The protective influence exerted by piles of débris is finely shown on the beach at North Manitou island. The upper beach along the south shore of the lake is usually very sandy and comparatively free from driftwood, while the North Manitou beaches are composed chiefly of gravel and shingle with heaps of driftwood piled about in the greatest confusion. The North Manitou flora is one of marked luxuriance, compared with the more southern type, and many mesophytic species are able to get a foothold in the more genial conditions there obtaining. The decay of the driftwood may also add no inconsiderable portion to the food materials of the beach plants.

The flora of the upper beach is much richer than that of the middle beach, both in species and in individuals, but here as there the vegetation is so sparse that the tone to the landscape is given by the soil. In the region as a whole the most characteristic species of the upper beach are *Artemisia caudata* and *A. Canadensis*.[1]

At nearly all places visited between Chicago and Beaver island Artemisia was present and commonly in abundance. Another plant associated almost everywhere with Artemisia is *Cnicus Pitcheri;* this thistle is seldom so common as Artemisia, but scattered specimens are pretty sure to be discovered on any

[1] Typical forms of both Artemisias have been found, as well as all intermediate gradations, and it is all but hopeless to try to determine which is the more abundant, without careful examination of all the plants in time of fruit. Both species are pubescent in beach and dune habitats, although *A. Canadensis* is the more so.

upper beach. A species scarcely less important in this connection is the beach pea, *Lathyrus maritimus*, another marine plant; locally the beach pea is often the dominant character plant, especially northward. Three other species are character plants over wide areas, as the above three are throughout. *Euphorbia polygonifolia* is a character plant at many stations between Chicago and Glen Haven; its absolute abundance is often as marked on the upper as on the middle beach, though its relative importance is much greater on the latter. *Agropyrum dasystachyum* and *Œnothera biennis* are as characteristic of upper beaches northward as Euphorbia is southward; Agropyrum especially is usually a dominant character plant north of Glen Haven.

None of the above six species are confined to the upper beach. Artemisia is found in most dune societies inland, especially in comparatively naked places. Cnicus is frequent on the dune complex, though less abundant than on the beach, as is also true of Artemisia. Lathyrus appears to be more restricted in its habitat, and in that sense is more typical of the upper beach, though it sometimes occurs on clay bluffs. Euphorbia occurs on the middle beach and also on naked dunes, though less frequently. Agropyrum, though characteristic of northern upper beaches, is still more characteristic of the embryonic dunes. Œnothera occurs on oak dunes and commonly also as a mesophyte.

At this point it will be well to emphasize one of the fundamental principles of ecological plant groupings. It is comparatively seldom that any single species can be regarded as perfectly characteristic of a formation, while a group of five or ten species can be so selected as to enable one to detect that formation almost anywhere within a large area. No one of the above six species can be regarded as perfectly typical of the upper beach, although Lathyrus approaches such a type, but together they form an assemblage that cannot be found in any other formation, except perhaps locally on the closely related beach dunes. Even on these beach dunes, which grade into the upper beach, the relative proportions existing between the above

species are very different from those found on the beach, and, as will be shown later, plant species occur on these dunes which are absent from the beach altogether.

Of the six chief character species of the upper beach, three (Œnothera, Artemisia, Cnicus) are commonly biennials, Euphorbia is an annual, while Lathyrus and Agropyrum are perennials with decidedly social habits through extensive rhizome propagation. Thus the perennial habit is much less common on the upper beach than on the dunes. The three biennials pass through the winter in the form of ground rosettes, tall shoots being sent up in the spring. Cnicus has a noteworthy protective covering of woolly hairs.

There are several plant species very characteristic of the embryonic dunes on the beach, which also occur on the upper beach proper, though rarely in great abundance. Notable among these plants are *Ammophila arundinacea*, and *Elymus Canadensis*. Ammophila occurs about equally throughout, while Elymus is much more characteristic northward; indeed on the northern upper beaches Elymus is sometimes as abundant as Agropyrum or Artemisia. About Chicago Elymus is a common character plant of the dunes, but rarely of the beach. Between Chicago and Muskegon *Asclepias Cornuti* is a frequent tenant of the upper beach. *Calamagrostis longifolia*, one of the chief character plants of the active dunes, is sometimes found on the beach, as are *Solidago humilis Gillmani* (plants large, but leaves not sharply toothed) and *Lithospermum hirtum*, which are more characteristic of rejuvenated dunes, fossil beaches, and heaths. *Cakile Americana* and *Corispermum hyssopifolium* occur but are less abundant than on the middle beach, although the latter is sometimes a prominent upper beach type. The forms discussed in this paragraph are perennials, with the exception of the last two; as they are all of secondary importance, in reality representing the vanguards of a flora which is more at home farther inland, there seems no necessity for any further defense of the idea that the upper beach flora is not typically composed of perennials.

All of the species discussed up to this time are herbs, passing the winter near the surface of the soil or underneath it. The exposure to which shrubs and trees are subjected during the winter is so severe on the upper beach that few of the many dune species have representatives there. The individual shrubs which brave these conditions are relatively scattered, while the plant body is stunted and bears signs of the severe environment provided by the beach. Much the commonest shrub, and the only one which occurs throughout, is *Prunus pumila*, the sand cherry. Poplars occasionally occur, *Populus monilifera* southward and *Populus balsamifera* (both the type and var. *candicans*) northward; so too, the willows, *Salix glaucophylla*, *adenophylla*, and *longifolia*.

The most striking feature of the plant life on the upper beach is the difference in its development at different localities. The luxuriant flora of the north is in marked contrast to the impoverished flora at the south end of the lake. The Dune Park beach, for example, is tenanted only by Artemisia, Cnicus, Corispermum, and a few scattering plants of other species. An upper beach on North Manitou island showed a great abundance of Elymus, Artemisia, Lathyrus, Œnothera, and *Populus balsamifera*, together with thirty-four other species which were rare to frequent. Among these other species several are of considerable interest: *Anemone multifida*, which also occurs on the beach at Beaver island and on several fossil beaches; *Prenanthes alba*, common in woods and thickets but seemingly out of place on the beach; *Equisetum hyemale*, which grows almost anywhere. On similar beaches at Empire, *Achillea Millefolium* and *Equisetum arvense*, two plants which never grow on the beach farther south, are very abundant. *Arabis lyrata* and *Polygonum ramosissimum* (?)[2], the former growing on the inland oak dunes about Chicago, occur on an exposed upper beach at the north end of Beaver island. The reasons for this great luxuriance of the northern upper beaches are not obvious. It has been previously stated that the greater abundance of driftwood on the more northern beaches may furnish considerable protection. This cause seems hardly

[2] A remarkable dwarf Polygonum with six stamens, very different from the type.

adequate to account for the great differences, and it may be that climatic or other less apparent factors may have to be called upon. The luxuriance of the northern forests as compared with those about Chicago may need in part a similar explanation.

Interesting beach conditions are to be found on some small islands that have recently formed on reefs in the vicinity of Beaver island. During the winter and spring blocks of ice laden with stones are stranded on these reefs; thus they are gradually built up to the lake level. Wave action comminutes the reef materials forming a soil suitable for plant life; the waves and winds also constantly add to the area of the islands. One such island is about 200 meters in length, five or ten meters in width, and scarcely thirty centimeters high. The flora of this unprotected island is a swamp flora, *i. e.*, the island is in its entirety a hydrophytic beach. Another island, somewhat larger and considerably older, has an altitude of one or two meters at its highest point. The beach toward the southeast, east, and northeast is hydrophytic, while that toward the northwest, west, and southwest is xerophytic. Undoubtedly the degree of exposure to the wind is the chief cause which determines the nature of the flora on this island. Not only is the wind more severe on the west beach, but the waves pile up more sand on that side of the island and hence produce a drier soil. The flora on this xerophytic upper beach is remarkably complete and diversified, showing a distinct zonal distribution. Above the middle beach there is a zone characterized by the dominance of *Elymus Canadensis*, then a zone of *Geranium Robertianum*, then a zone of *Artemisia Canadensis*, and finally a zone in which *Cornus stolonifera* (or *C. Baileyi* into which it grades) is the chief character plant. Scattered more or less with these are *Prunus pumila*, *Œnothera biennis*, *Lathyrus maritimus*, *Cnicus Pitcheri*, *Agropyrum dasystachyum*, and *Populus balsamifera*. *Pastinaca sativa* and *Geranium Robertianum* are common here, and are remarkable inhabitants of a xerophytic beach, since both are usually inland mesophytes. Two other plants occur on this beach that are south of their chief range and rare in the Lake Michigan region, *Tanacetum Huronense* and

Anemone multifida. The flora of this isolated island beach is remarkably prolific; scarcely a single upper beach type is absent. It is obvious that the means of plant dispersal are so uniformly successful, that almost an entire flora may be transported to a newly formed island within a few years.

One other common feature of upper beaches should be mentioned. As noted above, there are irregularities in the slope of the beach often resulting in depressions which reach below the water level. Such depressions may be called beach pools and of course have a hydrophytic flora; this flora, however, is not the flora of a hydrophytic beach. Beach pools are relatively protected from the action of winds and waves; the chief difference from a hydrophytic beach is that the latter is washed by the fresh waters of the lake, while the beach pools are far less constantly supplied with fresh water. The conditions in the latter approach somewhat those of the ill-drained inland sloughs between the sandy ridges. By far the most characteristic plant about the pool margins is *Juncus Balticus littoralis;* this species is more xerophytic than most of its genus, and often creeps well up on the xerophytic upper beach. *Triglochin maritima, Potentilla Anserina* and several species of Salix also occur about the margins of the pools.

4. *Fossil beaches.*

In regions where dunes are superposed upon the beach, portions of the beach may remain unoccupied by the wind-blown sand, appearing as islands in a sea of dunes. Or a beach which has been covered by the dune-complex may later be uncovered, exposing the gravel and shingle of an ancient shore. In any case these ancient or fossil beaches, separated as they are from the present beach by dunes, are more highly protected from the wind than the beaches which have been previously described. The cold winds lose little of their energy while sweeping up the gradual slopes of an ordinary beach, but their force is considerably broken by a line of dunes. Fossil beaches which have been uncovered by the dune complex occur at Dune Park, but to such a limited extent that a typical flora is not developed.

The most extensive fossil beach observed was at Glen Haven, where an area several hectares in extent has been denuded of its covering of sand to help supply the extensive dune complex. Similar but smaller fossil beaches were seen at Saugatuck and North Manitou island. Associated with the fossil beach is a formation which may not represent a beach at all. In the general description of the region, reference was made to the high terrace-like bluffs along the northern portions of the lake shore. These miniature plateaux, from which former sand dunes have doubtless been removed, exhibit a surface of gravel, which produces the appearance of a fossil or a true beach. The most extensive of these flat gravel-topped hills are at Glen Haven; similar but less extensive formations of this type were seen at Frankfort and North Manitou island.

The floras of the fossil beaches and the gravel terraces 120 meters above the present beach are essentially identical, although the latter apparently have a greater exposure. Both the beaches and terraces have a flora which resembles that of the upper beach in a general way, but there is a pronounced decrease of most of the typical beach forms and a pronounced increase of the more inland types. Thus the flora clearly illustrates the greater protection from exposure which is enjoyed on the fossil beach. The Artemisias are as characteristic of the fossil beaches and terraces as of the upper beach, but none of their five chief beach associates retain their prominence here. *Cnicus Pitcheri* occurs frequently, but chiefly at the lower level; *Euphorbia polygonifolia* and *Œnothera biennis* were observed but rarely and only at the lower level; Lathyrus, Corispermum, and Agropyrum were not found at all. In place of these upper beach plants the Artemisias have a new crowd of associates. In general the terraces and fossil beaches have four dominant character plants, *Artemisia Canadensis* (or *A. caudata*) as already named, *Solidago humilis Gillmani*, *Lithospermum hirtum* and *Andropogon scoparius*. Solidago and Lithospermum were noted as occurring at times on the upper beach, but they are far more common here. Andropogon was not observed on the true beach, but is very common on

fossil beaches and terraces, its scattered bunches or tufts forming one of the chief landscape features.

On the more northern fossil beaches several species are almost as characteristic as those named in the preceding paragraph. Prominent among these forms are *Zygadenus elegans, Campanula rotundifolia arctica*, and *Arenaria Michauxii;* northward these types are almost wholly confined to the fossil beaches or terraces, although Zygadenus is sometimes present on the upper beach. *Anemone multifida, Kœleria cristata* (*?*) and *Arabis lyrata* occur northward but are less frequent. A very interesting plant which sometimes frequents fossil beaches is *Hudsonia tomentosa*, a species noted for its habit of forming scattered clumps of densely tufted growths. Other occasional tenants of the terraces and fossil beaches are *Populus monilifera, Prunus pumila, Calamagrostis longifolia*, and *Solidago nemoralis.*

While the fossil beach looks backward to a true beach history, it commonly looks forward to a heath. Largely protected from the accumulation of sand, they furnish a situation favorable for the development of a juniper-bearberry heath. Such heaths are in process of formation at Manistee, North Manitou and elsewhere, and will be described in another place.

B. THE EMBRYONIC OR STATIONARY BEACH DUNES.

1. *Dunes of rapid growth* (*primary embryonic dunes*).

Many of the lake winds which blow across the beach have a surplus of energy, and are able to select out the finer grains of sand and carry them farther from the shore. The action of the wind in transportation is analogous to that of water. The finer particles are picked up bodily by the air currents, while the larger particles are blown or rolled along on the beach. Whenever an obstacle is met, some or all of the load is necessarily deposited by the wind. The coarser particles are deposited upon or about the obstacle, while the finer particles form a diminishing trail on the lee side. As soon as the deposition is sufficient to relieve the overladen wind, the trailing of sand ceases, and the wind continues with its lessened load until another obstacle is reached So long

as the wind blows continuously from one direction, the mound of sand keeps growing and the trail to the leeward becomes more and more conspicuous. Indeed, the growth increment is often greater during the later stages of a continuous wind current, since the growing mound of sand becomes more and more an obstacle to the progress of the laden wind. As a result of this action, there appears a topographic form with a steep windward side and a gently sloping leeward side.

When the wind changes, the trails of sand are no longer in the lee of the obstacle, but are more or less exposed to the wind, and hence are rapidly removed. The contour of the mound is changed and there results, just as before, a topographic form, steep to the windward but gently sloping to the leeward. It will thus be seen that it is always possible in dry weather to determine the direction of the last strong wind by observing the position and direction of the leeward trails of sand. A clump of grass with a poorly developed leeward trail may be seen in the foreground of *fig. 4*.

Under ordinary conditions no permanent results follow from such wind action as has been described, since one wind destroys the products of another. There is, perhaps, a tendency for sand to accumulate on the landward side of obstacles, since the energy of the lake winds is likely to be greater than the energy of winds from other directions. But no extensive dune formation can occur on the beach, unless the obstacle, which compels the wind to deposit its load, is itself increasing in size. A mound of sand, which is being built up by the wind, becomes more and more a formidable obstacle to the progress of the sand-laden currents, and it might be supposed that the growth of such a mound would continue indefinitely. Such does not appear to be the case on the beaches studied. The wind blows over the beach from so many directions and with such resistless energy that mounds of sand rarely accumulate without the aid of other factors.

The formation of beach dunes, then, depends upon something more than wind and sand. An obstacle is needed which will

grow *pari passu* with the dune, and such an obstacle is furnished by a number of perennial plants, which spread by means of rhizome propagation. These dune-forming plants must be perennials; otherwise the dune would be destroyed at the end of the growing season. Such annual dunes are very common on the beach. Clumps of Cakile have been seen, about which there is piled a miniature dune. In the same manner there may be formed biennial dunes about individual plants of Artemisia or Cnicus. A perennial dune, however, requires perennial dune-formers. A second necessity in a dune-former is the ability to spread radially by rhizome propagation, for only in this way can the area of the obstacle and the area of the dune be enlarged. The only notable exception to this rule is found in the case of cottonwoods and such perennial grasses as Andropogon and Elymus; these plants grow in groups or tufts and will be described later.

The plant which serves as an obstacle for the wind must also possess the power of growing out into the light when buried by the sand. This property permits the rise of the dune in altitude, as rhizome propagation permits the increase in area. Most plants are excluded by reason of this third requirement, partly because they are unable to rise above the sand when buried, and partly because stem elongation increases the difficulty of drawing up a sufficient supply of water from the soil. The roots of dune plants are often uncovered and exposed to wind and sand-blast action; hence plants unable to survive a period of root exposure cannot live in such a habitat. In short, a successful dune-former must be able at any moment to adapt its stem to a root environment or its root to a stem environment. The vicissitudes of existence on an embryonic dune are greater than anywhere else, except at a few points on the dune-complex. In addition to the above particular requirements, a dune-former must, of course, be perfectly equipped with a set of the most extreme xerophytic adaptations. Nowhere else except on the beach is there so great exposure to heat, cold, and wind.

The most typical and successful of all dune-forming plants

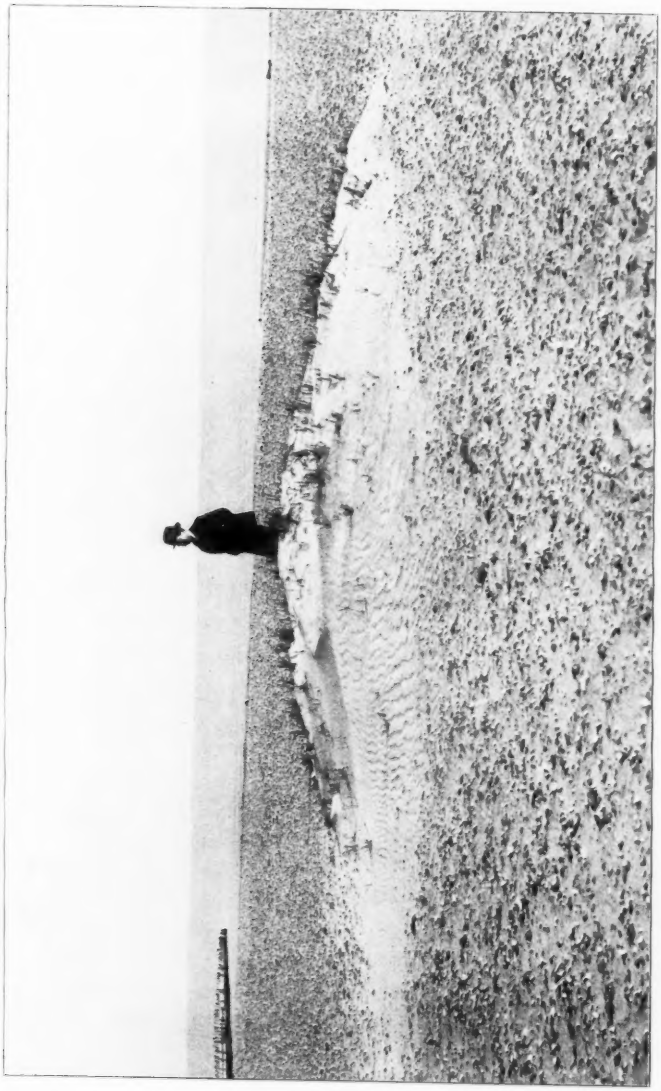


FIG. 2.—Embryonic dune on the beach at South Chicago, formed by the sand reed, *Ammophila arundinacea*. Leeward trail of sand at the left.

FIG. 3.—Embryonic Ammophila dune on the beach at South Chicago, some years older than that shown in *fig. 2*. Sinuous trough at the center, where there is no vegetation.

along Lake Michigan is the sand reed, *Ammophila arundinacea*. The life history of an Ammophila dune will now be given, and may be taken as the average life history of a stationary beach dune. Whenever a tuft of this or any similar grass gets a foothold on the upper beach, the sand drifts along and is lodged in between the stems and leaves, as already described (see foreground, *fig. 4*). The leeward trail of sand changes its position as the wind varies its direction, but the sand deposited between and around the blades of grass is not easily dislodged. The radial propagation of the tuft of grass causes an areal extension of the miniature dune. So, too, there is an increase in altitude, since the grass constantly grows higher in its endeavor to lift itself above the sand. This upward growth enables more sand to accumulate; in other words, the grass and the dune grow *pari passu* outwards and upwards. The result of several years of this symbiotic growth of dune and grass may be seen in *fig. 2*, which represents a small embryonic dune on the beach at South Chicago, Ill. The general contour of the dune is seen to be determined by the Ammophila; toward the left is the leeward trail of sand left by the last wind. *Fig. 3* represents an older and larger Ammophila dune on the same beach, viewed from the lakeward side and hence not showing any leeward trail of sand. Not only is the general contour of this dune determined by the Ammophila, but there will be observed a somewhat sinuous trough toward the center, where there happens to be no vegetation. This shows how readily the dune would be removed were it not for the plant life present. Thus Ammophila is not only an efficient dune-former but also a dune-holder.

While Ammophila is the most common dune-former and perhaps the best adapted for that difficult task of all our lake shore plants, many other species play a similar rôle. On the northern beaches *Agropyrum dasystachyum* is very common as a dune-former; its habit is exactly that of Ammophila, and consequently needs no description. *Elymus Canadensis* and *Calamagrostis longifolia* may be regarded as dune-formers, but they are of less importance than Ammophila and Agropyrum. A

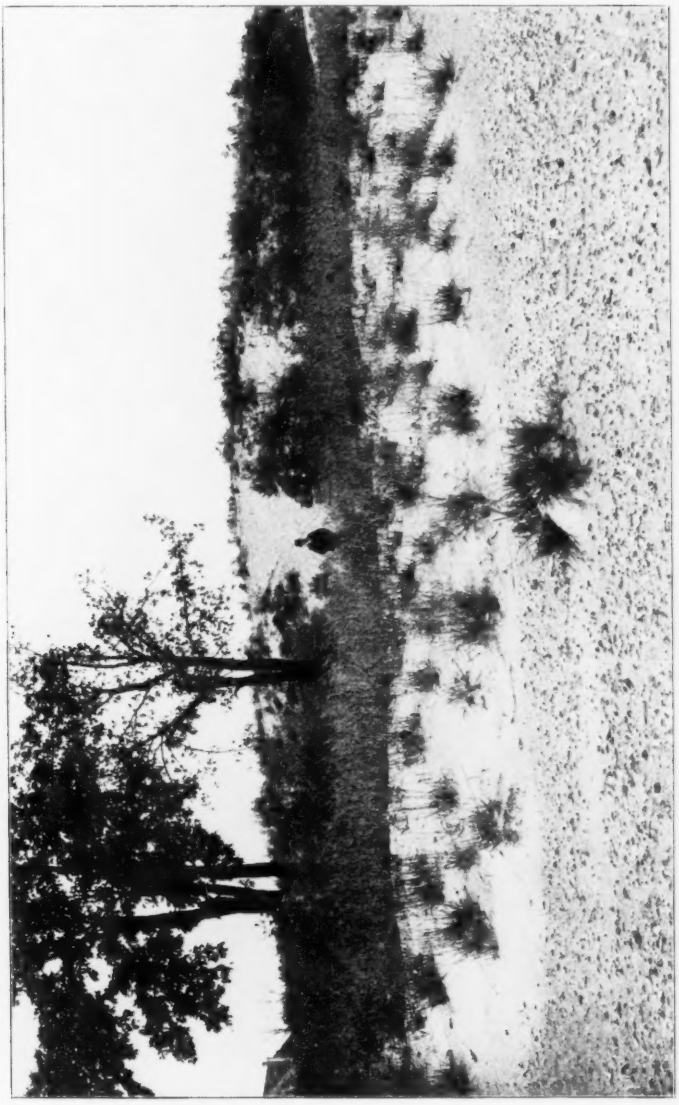


FIG. 4.—Embryonic dunes on the South Chicago beach. Tuft of grass in the foreground just beginning to collect sand, also with a leeward trail. Dune at the center formed by many tufts of Elymus acting together.

typical Elymus dune, as found on the South Chicago upper beach, is represented at the center of *fig. 4*. These grasses grow in tufts and do not have any extensive vegetative propagation, but the tufts may be so close together as to act like a large social clump of Ammophila.

Certain shrubs are of almost equal importance as dune-builders with the grasses. Among these, the willows, *Salix adenophylla* and *S. glaucophylla*, and the sand cherry, *Prunus pumila*, deserve especial mention. All of these shrubs have social habits, and rapidly increase their area of control in all directions. The willows are particularly well fitted to build up a perennial beach dune. They are about as well adapted to a xerophytic environment as are any of the grasses, and their vegetative increase is about as rapid. The fact that they are shrubs and have a greater power of vertical stem elongation makes them even better fitted to rise above the sand. When a shoot of one of these willows is buried, roots are sent out from all the buried portions, even up as far as the floral axis. The willows, too, can be uncovered without suffering serious injury. In short, the species of Salix are able to adapt their stems to a root environment, or *vice versa*, better than any other plants found along the coast. Hence the willows stand abreast of Ammophila as dune-formers. Another shrub that seems to have all the necessary requirements for a dune-builder is *Cornus stolonifera* (or *C. Baileyi*), though it is probably less fitted for a xerophytic life; however, Cornus dunes are by no means rare on the beach.

The only trees which make any significant contribution to dune formation are the poplars, *Populus monilifera* and *P. balsamifera*. Of these, the former is the more important, especially southward. These trees have little or no vegetative propagation of the willow type. Every year great numbers of cottonwood seeds germinate in protected depressions on the upper beach. As the young plants grow rapidly, it is not long before they form groups dense enough to retard the sand-laden winds. Thus a cottonwood dune is formed, a type which characterizes the Lake Michigan shore at very many places. A cottonwood dune

FIG. 5.—Embryonic dune at Dune Park, formed by the cottonwood, *Populus monilifera;* viewed from the leeward side. Trees partially buried. Steepness of slope shown by the streaking of the sand. Tendency of vegetation to creep up the lee slope.

a number of years old is shown in *fig. 5*. It is possible to see, even from the photograph, that the lower portions of the trees are covered by the sand. The growth of a cottonwood dune, therefore, is of a symbiotic nature, exactly as is the growth of an Ammophila dune, in spite of the great difference between the life habits of these two dune-formers.

The controlling part which plants play in dune formation is still further shown by the variations among the embryonic dunes as to area, shape, and height. Dunes that are formed by Agropyrum, Ammophila, or Salix are capable of indefinite areal expansion, since these plant types have extensive vegetative propagation. Populus or Elymus dunes, on the other hand, always retain essentially the same area, since there is little or no vegetative reproduction, and since the opportunity for any further development of seedlings is removed. Young seedlings are often found in the moist sand of the depressions, but never in the dry sand of the dunes. The Agropyrum dunes are always very low, seldom if ever a meter in altitude. The Ammophila dunes are higher because this latter plant type has a greater power of upward growth than has the former. Both the Agropyrum and Ammophila dunes are alike in being relatively large and low, with slopes almost as gentle as those of the beach. The Salix dunes are equally large, but higher and steeper because of the greater power of upward growth. The Prunus dunes are very small because of the slight vegetative propagation, and yet they are relatively high and steep because of the pronounced power of upward growth.

The cottonwood dunes are the highest of all, often having an altitude of several meters, because the cottonwoods grow higher than any other dune-former; they are also the steepest because there is no vegetative propagation. The steep slope of a cottonwood dune is shown in *fig. 5;* the marks in the sand at the right are the paths made by the movement of the sand down the steep slope, and indicate a gradient of about 30°. *Figs. 2* and *3* indicate the gentle slope of the Ammophila dunes. The cottonwood dunes are commonly long ridges parallel to the lake

shore. This is partly due to the fact that the depressions in which the seeds germinate are parallel to the shore, because of wave action. The prevalence of lake winds perpendicular to these ridges also helps these topographic forms to retain their original shape. Summing up this matter, then, the area of a beach dune is determined chiefly by the amount of the vegetative propagation of its tenants, the steepness is determined by the rapidity of this propagation, and the altitude by the power of the dune plants to increase in height.

Of the dune-forming species, *Ammophila arundinacea* and *Salix adenophylla* are the most abundant, occurring almost everywhere that beach dunes exist. These two species are most at home when half-buried in the wind-blown sand, and occur much less frequently in other associations. *Prunus pumila* and *Calamagrostis longifolia* occur throughout the region, but are less characteristic of the beach dunes than are the first-named species. Prunus is common on the upper beach, as already shown, and also on the heath; Calamagrostis is particularly characteristic of the larger active dunes. *Agropyrum dasystachyum* is very common at Glen Haven and farther north, and, like Ammophila, is most at home on the beach dunes. *Populus monilifera* is very common south of Glen Haven; the cottonwood dunes are usually formed farther inland than the other types. This species is replaced northward to some extent by *Populus balsamifera* and its variety *candicans* (both sometimes on the same tree!), though this poplar is much less of a dune-former than the cottonwood. *Salix glaucophylla* is frequent on the beach dunes, especially southward, but is more characteristic of the swamps; the same may be said of *Cornus stolonifera*. *Elymus Canadensis* is not abundant anywhere on the beach dunes.

An interesting corollary may be deduced from the last three paragraphs. Since various dune forms are caused by differences in the life habits of the dune-forming species, it follows that the distribution of certain topographic forms coincides with the distribution of the dune-formers. Low dunes of the Agropyrum type are not found at the south end of the lake. The steep ridgelike

cottonwood dunes are common southward, but rarer northward, since cottonwoods are rarer northward. This is only one of the many cases where ecology helps to interpret physiography.

The dune-forming plants are not the only tenants of the beach dunes. Most of the species that grow on the upper beach are also frequently present on the dunes. Those of especial importance are *Artemisia Canadensis* (or *A. caudata*), *Cnicus Pitcheri*, *Lathyrus maritimus*, *Euphorbia polygonifolia*, and *Corispermum hyssopifolium*. By reason of its extensive vegetative propagation, *Juncus Balticus littoralis* sometimes serves as an obstacle to sand-laden winds, and by a limited subsequent growth results in the formation of miniature dunes. *Lithospermum hirtum*, though more characteristic of embryonic heaths and rejuvenated dunes, sometimes ventures out upon the beach dunes. It should be likewise noted that any of the dune-forming species are likely to grow on dunes that are formed in the main by others, although the vegetation of individual embryonic dunes is often composed of a single species.

Though no plant formation anywhere can have a much larger percentage of plants that are entirely independent of other plants, the beach dunes, nevertheless, have occasional forms that are parasitic, saprophytic, or epiphytic. Various unidentified Basidiomycetes have been found in the most open places, deriving their nutriment from buried driftwood. The most notable parasite found was *Aphyllon fasciculatum*, a plant which derives its nutriment through attachment to the roots of Artemisia. Lichens are abundant on the cottonwoods at all places that are not directly exposed to a fierce sand-blast action. Common lichen species in such places are *Physcia stellaris*, *Theloschistes concolor*, and *Placodium sp.*

Interesting beach dunes were seen on the shores of two small inland lakes, Crystal lake, near Frankfort, and Fount lake, on Beaver island. In each case the lakes approach a dune area near the shore of Lake Michigan, suggesting the probable origin of the sand; there can be no question, however, but that the sand composing these beach dunes was washed up by the waves of

the small inland lakes and worked over by the winds, exactly as described in the preceding pages. The dune-forming winds at Crystal lake are easterly winds, chiefly because the source of sand is on the west side of the lake, and it is on the west shore that the dunes are located. There are typical Ammophila dunes at this point. Among the other plants growing here are Artemisia, Cnicus, Populus, Cornus, Prunus, Lathyrus, Œnothera, Corispermum, Calamagrostis, Elymus, and Juncus. At no place on Lake Michigan was a more typical and varied beach and beach dune flora observed than on the west shore of Crystal lake.

2. *Dunes of slow growth* (*secondary embryonic dunes*).

Dune formation is by no means confined to the upper beach, but may take place anywhere that the sand is able to collect, provided the plants at that place are fitted to be dune-formers. The formation of dunes on the dune-complex and on rejuvenated dunes is essentially like that on the upper beach, and will be discussed later. New dunes of a very interesting type are in process of formation on many fossil beaches and on the gravel terraces. As has been previously stated, the terraces and fossil beaches are better protected from the wind than is the upper beach, and there is in consequence not only a more luxuriant flora, but also a different plant assemblage. The sand which blows across these places, though less in quantity and less furiously driven, nevertheless is capable of dune formation if the proper plant species are present. Several of the beach dune-formers also occur on the terraces and fossil beaches, and build up small dunes. Among these are Ammophila, Calamagrostis, Prunus, and Populus.

Among the dune-formers on terraces and protected fossil beaches, one of the most interesting is *Andropogon scoparius*. This grass grows in tufts and is very abundant, as has been already stated. About each tuft a mound of sand has often collected. A photograph showing the striking appearance of an area of Andropogon dunes was unfortunately spoiled, but its appearance is much like that of an area of *roches moutonnées*, as

figured in geological works. Hundreds and sometimes thousands of these miniature dunes may be seen in a single landscape. *Arctostaphylos Uva-ursi* and *Juniperus Sabina procumbens* are dune-formers within moderate limits. Both of these shrubs are procumbent creepers, and hence unable to rise above the sand to any considerable height, probably never as much as a meter above their original position. It is for this reason that such hardy plants as these cannot grow successfully on an upper beach that is exposed to extensive sand drifting. The above three species are the most prominent dune-formers in protected places. Arctostaphylos dunes occur throughout, and are not confined to fossil beaches, but are also common on exposed heaths. The Andropogon dunes were not seen except on fossil beaches, although this grass is common along the entire coast. The Juniperus dunes occur chiefly northward.

The dune formation seen on east coasts was chiefly of this small, slow-growing, secondary type. The dunes at Waukegan, in part at least, are formed by Juniperus. On the east shore of Beaver and North Manitou islands, there are a number of low dunes formed conjointly by Juniperus and Arctostaphylos. There are low slow-growing Juniperus dunes on the shore of Fount lake on Beaver island; in addition to the procumbent juniper, *Juniperus communis* and *Gaylussacia resinosa* assist in dune building here. The Andropogon dunes are better developed on the fossil beaches of North Manitou island than at any other point visited. On these same fossil beaches, *Hudsonia tomentosa* serves in a small degree to collect the wind-blown sand. On the east shore of North Manitou island, the pasture grass, *Poa compressa*, forms miniature dunes.

Near the beach at South Chicago there are swampy depressions tenanted by *Potentilla Anserina* and *Polygonum Hartwrightii*, plants which are best developed in low grounds but which often creep up to higher levels. On these higher levels near the beach they collect the drifting sand and are able to form low dunes, similar to Arctostaphylos. These plants show a most surprising plasticity, since a single individual developed in a swamp is able

to adapt itself to a mild type of dune existence. Another swamp plant, *Cephalanthus occidentalis*, occurs near the same beach and in a similar way helps to build these low slow-growing dunes. The conversion of swamp plants to dune plants will be discussed more at length in another place.

The most extensive area of dune formation on the beach was seen on the west shore of Beaver island. *Fig. 6* shows a

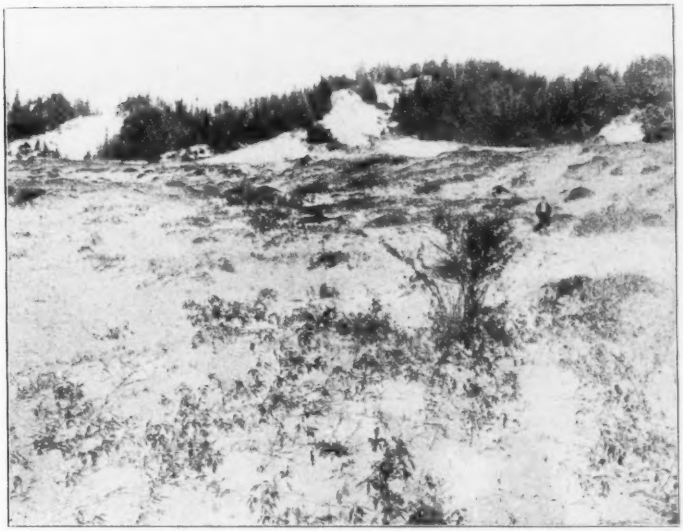


FIG. 6.—Embryonic beach dunes at Beaver island. Primary Prunus and Salix dunes in the foreground. Secondary Arctostaphylos dunes superposed on primary dunes, at the center of the picture. Old lines of established coniferous dunes in the background, becoming rejuvenated at several points.

small portion of this area. This place is of peculiar interest because there is a perfect series of gradations between the rapidly growing dunes first described and those of the slower growing type. Toward the beach proper (foreground, *fig. 6*) there are dunes formed by Salix, Prunus, and other high-grade dune-builders. Farther back, toward the taller and older dunes

of a previous epoch, there may be seen low dunes built by Arctostaphylos, Juniperus, and *Potentilla fruticosa*, small dune excrescences on a general dune substratum. The life-history of these dunes appears to have been as follows. First a stage of dune formation by such plants as Salix, then, as vegetative propagation allowed these plants to encroach more and more lakeward upon the broad beach, new dunes were formed nearer and nearer the lake. Or, perhaps, there was a recession of the lake and a consequent extension of the beach into new territory; these new dunes may have thus been formed farther and farther lakeward, keeping pace with the advancing shore line. In any event, the interposition of a new row of dunes between the lake and those first formed essentially changed the life conditions on the latter. The row of dunes nearest the lake serves as a windbreak. The first row catches most of the drifting sand, and the second catches most of what remains. This fact makes it possible for the slow dune-formers to inhabit the more inland of the ridges. Expressed in other words, the high-grade or primary embryonic dunes encroach upon the lake, not by the actual advance of an individual dune in that direction, but by the formation of new ones; in like manner the low-grade or secondary embryonic dunes encroach upon the former type, using the topographic form of the primary dune as a base of operations, and building new dunes as low excrescences upon the old.

The advance of a dune area toward the lake, as just described, shows how the coastal belt of dunes may grow wider as the years pass by. In another place it will be shown how they may also grow wider by the actual advance of an individual dune upon the land. In concluding the section on the embryonic dunes, it may be well to emphasize in another way the radical difference between the two types that have been discussed. Their intimate gradation, as shown at Beaver island, is by no means the universal fact. Perhaps it is even more common for one of the primary type to leave its original habitat and wander across the country as an active dune. The secondary type never has that history; an Arctostaphylos dune almost always grows into a heath.

C. THE ACTIVE OR WANDERING DUNES. THE DUNE-COMPLEX.

1. *Transformation of stationary into wandering dunes.*

The symbiotic growth of the beach dunes and their builders may go on for years, but a prolonged existence of these relations is unlikely. As the mounds get larger and higher the conditions for further accumulation of sand become, if anything, more favorable. It is not so with the plant tenants, for each year they are raised farther from their chief base of supplies, the water level. It is probable, also, that the desiccating influence of radiant energy and wind upon the aerial organs becomes greater and greater as the years go on, because of greater exposure at the higher levels. Again, the dune-formers, although perennials, do not have an indefinite duration. The life cycle of the cottonwood is relatively short for a tree. All of the other prominent dune-formers spread more or less by vegetative propagation, so that it is difficult to determine a definite life cycle. Even though an existence of indefinite duration might be secured through vegetative propagation, many individual shoots must die in the course of time.

In one way or another, then, dune formation ceases and another phase of dune history begins. There is here an end of the stationary beach dunes, a beginning of the wandering dunes. When the plants are no longer able to oppose its progress, the first effect of the untrammeled action of the wind is seen in a tendency to reshape the topographic forms. The beach dunes heretofore described are more or less symmetrical, because of the tendency toward symmetrical plant growth. A dune fashioned entirely by the winds without the assistance of plants is never symmetrical. The windward slope has a very gentle gradient, usually about 5°, and because of the destructive action of the wind, this slope is topographically rough and uneven. The leeward slope, however, is much steeper, averaging about 30°, and is very smooth and even, because determined by gravity instead of wind. The wind sweeps up the gentle windward slopes, blowing or rolling the sand along until the crest is reached; here the

sand is deposited by the wind and it rolls down the steep slope, spreading itself quite evenly. *Fig. 17* shows an average gentle windward slope, *figs. 13–15* steep leeward slopes.

The Prunus dunes are particularly favorable for a study of the origin of an active dune, since their form is most at variance with that of the wind-shaped dune, as described above. A Prunus dune is commonly a low cone more or less rounded at the top. As soon as the plants are dead, and sometimes long before that event occurs, the wind endeavors to reduce the windward gradient by removing the sand toward the top and blowing it over on the other side. In this way the roots are exposed and existence made less endurable, if the plant is still living. Prunus dunes with roots exposed on the windward side are common at Dune Park, Beaver island, and elsewhere. On the terrace at Glen Haven, some dunes have been carried beyond their former resting place, leaving the scraggy clumps of Prunus roots at the rear.

What has been said of the Prunus dunes holds more or less for the other types. The cottonwood dunes especially are peculiarly subject to the destructive attacks of the wind, since their shape also notably fails to correspond with that of a normal wind-made topographic form. The lower Ammophila, Salix, and Agropyrum dunes are less likely to suffer destruction, and yet small Ammophila dunes were seen on the dune-complex at Glen Haven that had been blown away from their first abode, leaving the Ammophila stranded at the rear. Even while living, these dune-formers were unable to hold the dunes which they had helped the wind to build; much more when dead are they likely to have the dune swept on beyond them.

The destructive action of the wind and the transformation of a stationary into an active dune are very much retarded by the tenacity with which the stems and roots retain their place, even when dead. A plant which thus has the power to hold its position and keep the sand from being blown away is commonly called a sand-binder. In this connection it may also be called a dune-holder, as it has been already called a dune-former.

Perhaps the most tenacious of all the dune-holders on the coast of Lake Michigan is *Calamagrostis longifolia*. This grass, as has been seen, is not of first importance as a dune-builder, but when it has once built up a dune it seems almost impossible to dislodge it. At the left of the basswood tree in *fig. 23*, there is shown a clump of Calamagrostis directly facing the prevailing wind at the summit of a mound, and stubbornly holding its position. The leaves, stems, and roots are all stiff and wiry, almost perfectly resisting the mechanical action of the wind. The roots in the sand form a network so dense that it is almost impossible for the wind to remove the sand from among them.

From an economic standpoint, *Ammophila arundinacea* is a more successful dune-holder than is Calamagrostis, but its greater success is due to its extensive vegetative propagation. The dense social growths of Ammophila make it difficult for the wind to get a start in the process of sand removal, whereas the sand can be readily picked up from between the more scattered tufts of Calamagrostis. An individual tuft of the latter, however, seems to be much more resistant than a tuft of Ammophila. Calamagrostis, too, grows in more exposed situations than does the other grass, and hence is a valuable dune-holder in places where Ammophila might not thrive at all.

Another noteworthy dune-holder is *Prunus pumila*. A very common sight on the upper beach is a truncated cone literally covered at the summit and sometimes on the sides with a dense tangle of dead stems and roots of the sand cherry. The wind has removed all the sand which it can reach and is obliged to wait until the stems and roots decay sufficiently to allow the wind to blow them away and get at the sand beneath. Prunus is one of the first plants to succumb before the dune in the process of dune formation; perhaps its life cycle is normally short, but more probably the process of drawing up water a greater and greater distance each year compels the plant to give up the unequal struggle.

Sooner or later the dead roots and stems of the dune-holders are all removed, and the wind becomes the undisputed master of

the situation. If there is a sufficient amount of sand still remaining, the once stationary dune begins to move, not bodily, of course, but none the less steadily and surely. The sand is swept up the low gradient of the windward side, deposited at the crest, and carried down the steep leeward slope by gravitation. In this manner successive parallel layers of the windward slope are carried over the crest, and the dune as a whole advances inland. The simple life-history just outlined is the exception, not the rule. Much more commonly the sand is scattered in many directions, collecting wherever new lodging places can be found. These processes of deposition and removal, dune formation and dune destruction, are constantly going on with seeming lawlessness. However, in the district as a whole the sand is constantly increasing in quantity, whatever may be true of the individual dunes here and there. The outcome is certain to be a wandering dune in the process of time, unless the actions of the wind and wave are checked. Because of the complexity of the conditions when the movement across the country becomes a conspicuous fact, it seems well to apply the term dune-complex to the totality of topographic forms which make up the moving landscape as a whole.

2. *Physical and biological features of the dune-complex.*

It will not be necessary to trace farther the changes involved in the transformation of simple beach dunes into a dune-complex, although the coast of Lake Michigan shows all of the intervening stages. Inasmuch as a single dune-complex illustrates almost all conceivable conditions of a dune's life-history, a careful description of a typical dune-complex will involve all of the essential points. The dune-complex is best developed at Glen Haven, Mich., and Dune Park, Ind. All of the essential features are present in both areas, though developed on a grander scale at Glen Haven. The Dune Park area has been most carefully studied, and most of my photographs were taken there.

The dune-complex is a restless maze. It is a maze because all things that a dune ever does are accomplished there. While

there is a general advance of the complex as a whole in the direction of the prevailing winds, individual portions are advancing in all directions in which winds ever blow. It is not at all uncommon to find small dunes advancing over the dune-complex back toward the lake. At Dune Park the main line of advance is southeast, yet some small dunes advance toward the northwest, because taller dunes are situated between them and the lake. These little dunes in the lee of large ones are protected from the westerly and northerly winds but feel the full force of the easterly and southerly winds, and hence advance contrary to the prevailing direction. It is thus a common sight to see two dunes advancing to meet each other; when they come together, of course the two dunes become one and move in the direction of the prevailing winds. From this account it is easy to see that small dunes on the complex may advance in any direction, provided only that they are protected from winds blowing in other directions.

The dune-complex, however, is much more than a maze of little dunes wandering in all directions. At many points there are to be found the stationary embryonic dunes that have been previously described. All stages of their life-history may be seen; the beginning, the climax, the destruction. Here and there the wind sweeps out great hollows, which reach down almost to the water level. Great troughs are carved out by the wind, chiefly at right angles to the lake, but also at all other angles. Here and there vegetation has obtained a foothold on the complex, thus converting portions of it into an established dune. These established dunes may become rejuvenated, or the vegetation may spread until it covers large portions of the complex. The most striking feature of the dune-complex, then, is its topographic diversity.

To one who visits a dune-complex season after season, another feature comes to be as striking as its diversity, and that is its restlessness. From a distance the complex seems always the same, a barren scene of monotony, but the details are never twice alike. A little dune arising on the complex has become

enlarged, another has passed from existence without leaving a trace behind. Where a dune was advancing last year, there is now, perhaps, a hollow swept out by the wind. Where last year was a hollow there may now be seen the beginnings of a flora, or again the flora of a former year may have been buried out of sight. The dune-complex, then, is not only a maze, but also a restless maze.

FIG. 7.—Trough-shaped wind-sweep at Beaver island. Dead roots and branches of plants that have been torn up. Embryonic dunes in the background formed of sand brought from the foreground. Sparse annual vegetation in the wind-sweep.

It might seem impossible to unravel the tangled threads of the dune-complex; it is, indeed, impossible to write the details of its history. There is, however, a simplicity in the complexity. While little dunes advance in all directions, the complex as a whole advances in the direction of the prevailing wind. While there are troughs at all angles, the main troughs are likewise in the direction of the wind. The complex is like a river with its

side currents and eddies at many points, but with the main current in one direction.

It has already been stated that the windward slope of an advancing dune is very gentle, averaging perhaps about 5°. That portion of the windward slope up which the main wind currents pass is also trough-shaped and may be called a wind-sweep. *Fig. 7* shows a small trough-shaped wind-sweep at Beaver island; the direction of advance is from the foreground to the background. In the path of the wind there may be seen dead branches, the remnants of a vegetation that has been swept away. In the background are small dunes which have been formed by sand carried along the trough by the wind. A wind-sweep more characteristic of the dune-complex is shown in *fig. 17*. Here, likewise, the prevailing wind direction is up the gentle slope away from the foreground. At this particular place there is in reality much more of a trough than is shown in the photograph, since there is a conspicuous rise both at the right and at the left. Just beyond the pines in the background there is a steep pitch downward, the advancing lee slope.

The most remarkable wind-sweep at Dune Park reaches down almost to the water level, appearing like a cañon, by reason of its steep sides from ten to twenty meters in height. This sweep, unlike most of the troughs, is curved so that a wind entering it as a northwest wind becomes a west and finally a southwest wind, and actually contributes to the advance of a dune toward the lake, as will be discussed more fully at another place in connection with *fig. 10*. The concentration of the wind energy which these gorge-like wind-sweeps permit is something remarkable. At no place is the destructive power of the wind upon the vegetation felt more keenly than along the sides of these deeper wind-sweeps. The foreground of *fig. 22* shows the upper part of one of these troughs, and gives a vivid impression of the wind's destructiveness.

The advancing lee slopes, as has been previously mentioned, have a gradient in the neighborhood of 30°. The slope is exactly that at which sand, whose grains have the size and cohe-

siveness there found, will lie. *Figs. 9, 13, 14,* and *15* give some conception of the striking features presented by a landscape of which an advancing dune forms a part. Nowhere can there be a sharper line in nature, nowhere a more abrupt transition. The height of these slopes above the country on which they are advancing varies from almost nothing up to thirty meters at Dune Park. The Glen Haven dunes are far more imposing, since there is an almost unbroken line of advance for four kilometers, while the average height is from thirty to sixty meters above the territory on which they are encroaching.

The vegetation of the complex proper is exceedingly sparse. In the winter it appears almost a barren waste. The one plant which seems to be at home in all locations, whether wind-sweeps, exposed summits, or protected lees, is the bugseed, *Corispermum hyssopifolium*. This plant is an annual, and has been previously mentioned as a tenant of the beach and the beach dunes. The bugseed is shown in several of the photographs, but best in the left foreground of *fig. 12*. The seeds are winged and readily dispersed by the wind. Furthermore they germinate rapidly during wet spring weather. This power of rapid germination is a necessary condition of success, since the surface layers of sand dry off very quickly after the wet weather has ceased. The plants are obliged not only to germinate rapidly but also to send roots deep enough to reach beyond the surface desiccation. Even this perfectly successful plant species is often absent from large areas on the dune-complex, probably because of the difficulty which the seeds meet in finding lodgment. It is only an exceptional seed which is allowed to remain stranded on the complex, and many of the seeds which succeed in finding lodgment are likely to be buried too far below the surface to permit germination.

Another plant which deserves especial mention is the cottonwood, *Populus monilifera*. The plasticity of this species is remarkable. Normally at home along protected river bottoms, it is yet able to endure almost all of the severe conditions of the dune-complex. Mention has been made of its importance as a

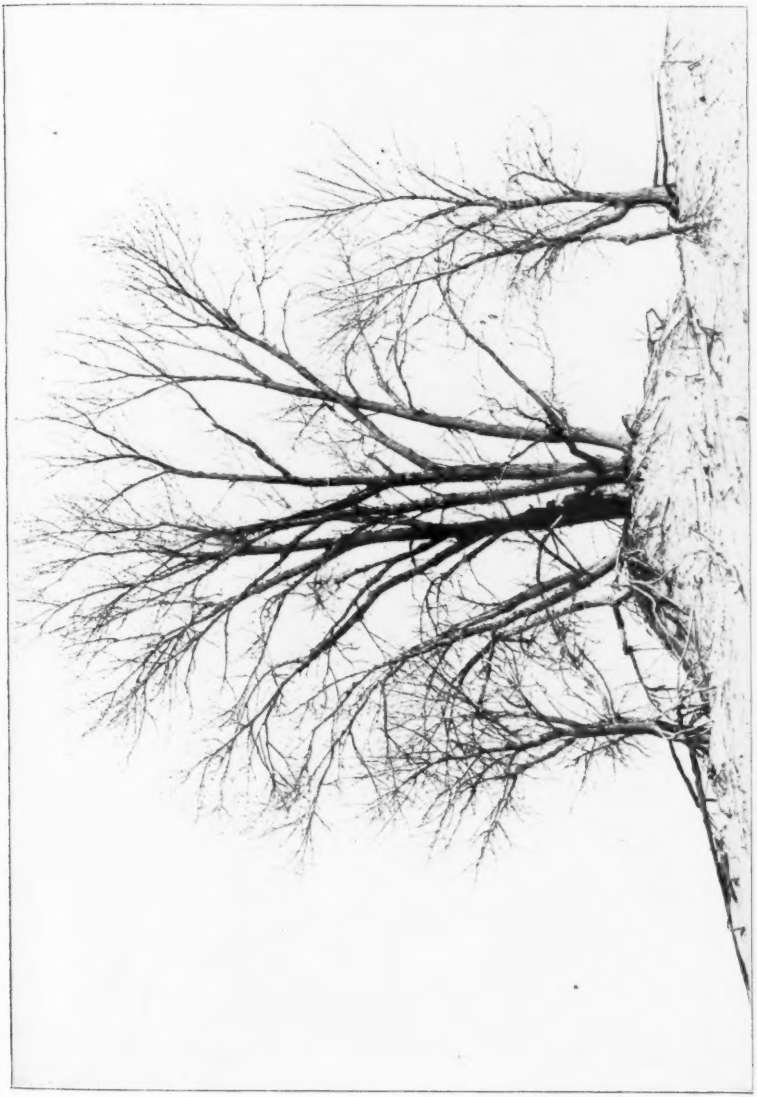


FIG. 8.—Group of cottonwoods (*Populus monilifera*) at an exposed position on the dune complex at Dune Park. Exposure of roots, due to denuding action of the wind. View taken in winter.

dune-former, and *fig. 5* shows a group of cottonwoods on an embryonic dune partially buried by the sand. Photographs might have been secured showing trees, presumably fifteen meters in height, buried up to the topmost branches and yet alive and vigorous. *Fig. 8* (taken in the winter) shows a vigorous clump of trees, high up on the dune-complex, with their roots exposed by reason of the removal of the sand from around them. Much more striking examples than this have been seen of living trees standing high up in the air, and yet with no apparent injury. In one respect the cottonwood is a hardier plant than Corispermum; it is a perennial and hence passes the winter on the dunes. In the summer the winds are much more moderate, and the chances of being covered or uncovered are more remote.

Two grasses are more or less at home at many places on the complex, *Ammophila arundinacea* and *Calamagrostis longifolia*. Of these the latter is the hardiest and most typical of exposed positions, such as shown at the left in *fig. 23*. The tenacity with which Calamagrostis holds its ground has already been mentioned. On the Glen Haven complex, Ammophila is particularly abundant. In some places it is so thick and green as to look almost like a field of grain from a distance; yet even here, the luxuriant growth is only in the protected places, and none at all is found in the most exposed situations.

The reasons for the scanty plant life on the exposed portions of the dune-complex are not far to seek. First of all it is not due to the scarcity of water in the soil. Even after a long period of drought in summer, the sand is cool and moist at a short distance below the surface. The upper dry layers of sand act as a non-conductor of heat and prevent the evaporation of the water that lies beneath. The height of the underground water level beneath the dunes was not ascertained. Indeed it is not at all necessary to determine where this level actually resides, since there is enough water far above it to support a luxuriant vegetation, if that were the only factor concerned.

In spite of the water supply in the dune sand, the scanty flora of the complex is characterized by the possession of the

most pronounced xerophytic adaptations to be found in this latitude. These xerophytic structures will be discussed in the second part of this paper. At this point it is necessary only to state that in the main they are to guard against excessive transpiration, such as is induced by the unusual exposure to wind, heat, and cold. In a certain measure one might attribute these xerophytic adaptations to an insufficient amount of water in the soil, since, were they absent, the soil water would soon be used up. But it is much more important to discriminate, as ecologists are now coming to do, between conditions in the soil and those in the air. A plant may have its roots in the water and yet be exposed to a xerophytic air; in that case the aerial organs will be provided with xerophytic adaptations, as is the bulrush. Schimper, in his recent plant geography, goes still farther and calls some plants hygrophytic at one season and xerophytic at another. Perhaps the ultimate definition of a xerophyte will be a plant that is endeavoring to reduce its transpiration.

Directly or indirectly, the wind is the factor primarily responsible for the scarcity of vegetation on the dune-complex. Incidentally, as has been stated, the wind dries up the soil and increases transpiration. Incidentally, too, the mechanical action of the wind in connection with the sand-blast is destructive to vegetation. The cardinal destructive influence of the wind, however, consists in its power to cover and uncover the dune plants. Two plants have been referred to as peculiarly well adapted to dune life, Corispermum and Populus. The former is a small herb, and unable to endure either covering or uncovering to any great extent. This plant, however, is an annual of short duration and does not exist during the periods of the greatest wind activity.

The cottonwood, which has been shown to be best fitted to withstand the instability of dune conditions, might be expected at first to grow in abundance there. It has almost unlimited powers of endurance in all conditions of exposure; it may be covered to the upper branches, or may have its roots uncovered to a depth of two or three meters, and yet flourish. Its failure

to make any considerable headway on the complex is due partly to its relative inability to extend its area by vegetative propagation, partly to its short life cycle, and partly to the impossibility of germination. Thus a group of cottonwoods, which germinated when the conditions were more favorable and have been able to withstand the severe environment of the dune-complex, cannot appreciably extend their area, nor can they live for many years. New trees cannot take their place, because of the inability of the cottonwood seed to germinate on the higher exposed portions of the complex. These seeds sprout much more slowly than those of the bugseed, nor could the young plants withstand the winter conditions on the complex, even should they germinate. Furthermore, the likelihood of any considerable lodgment of cottonwood seeds is excluded by their light cottony appendages.

THE UNIVERSITY OF CHICAGO.

[*To be concluded.*]

BRIEFER ARTICLES.

A NEW COLLETOTRICHUM DISEASE OF THE PANSY.

(WITH FIGURES)

DURING the past season a leaf-spot disease affecting the cultivated pansy has been observed in several localities in Massachusetts, which has been found to be caused by a hitherto undescribed fungus. In at least one instance the disease has shown itself to be a very destructive one, and a consideration of its economic importance will be found in the annual report of the Hatch Experiment Station of the Massachusetts Agricultural College for 1898. Professor B. D. Halsted informs me that the same thing has been found in several places in New Jersey, though not abundantly, and has very kindly sent me specimens for comparison. It is the purpose of this note to describe this form, which seems likely to become abundant in this section at least.

The disease is characterized by the appearance upon affected leaves of dead spots, at first small with a distinct black margin, but soon becoming larger and giving the leaf an appearance very similar to that produced by the well-known violet leaf-spot (*Cercospora Violæ* Sacc.). The petals also become affected, dying in spots and on the edges. Many of them do not develop fully, and thus the blossom appears malformed and unsightly. Such flowers produce no seed and in a large field of pansies raised for seed, where the disease has been seen at its worst, a considerable loss was experienced on this account. Besides this, moreover, many plants were killed outright, making the damage still greater.

The fungus which causes this trouble is a form which evidently belongs in the genus *Colletotrichum*, though in very fully developed material forms are found which closely approach *Vermicularia*, the acervuli having a considerably developed pycnidium. The species apparently stands near the boundary line between these two genera (if one exists), but comes closer to *Colletotrichum* as generally understood. I append a description of this form, for which I propose the name

Colletotrichum Violæ-tricoloris, n. sp.— Parasitic on leaves and petals of cultivated pansy, *Viola tricolor* L., causing pale yellowish spots upon

the leaves and dead areas on the petals, together with more or less deformation of the blossoms. Spots at first orbicular and definite in outline but later becoming confluent and irregular. Acervuli numerous, 50–150 μ in diameter, often confluent; stroma usually only slightly

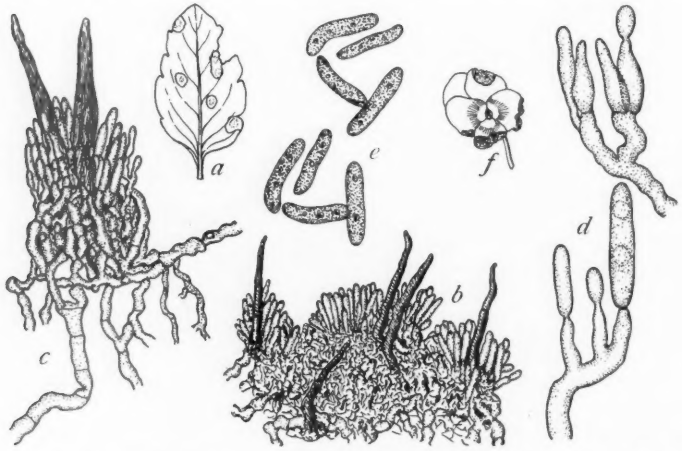


FIG. 1. COLLETOTRICHUM VIOLÆ-TRICOLORIS R. E. Smith: *a*, affected leaflet; *b*, several confluent acervuli with mycelium, setæ, and conidia; *c*, single acervulus, more enlarged; *d*, basidia and production of conidia; *e*, conidia; *f*, affected blossom.

developed but sometimes abundant and forming a sort of pycnidium, closely approaching *Vermicularia*. Setæ mostly single or in pairs, 20–70 μ long, deep brown, once or twice septate, tapering gradually to a point. Basidia short, hyaline. Conidia oblong or slightly curved, with blunt ends; hyaline, continuous, granular with vacuoles; averaging 20 × 5 μ.— RALPH E. SMITH, *Amherst, Mass.*

A NEW BIENNIAL-FRUITED OAK.

(WITH PLATES II, III)

Quercus ellipsoidalis, n. sp.— Trees 3–10^{dm} in diameter, 8–20^{m} tall, with an oblong head, the spray fine and repeatedly dividing, the limbs often descending low down on the trunk and the lowermost drooping. The bark is close, rather smooth, divided by shallow fissures into nar-

row, thin, flat plates, 5–15^{cm} long, 1.5–3.5^{cm} thick, frequently connected by cross plates. It is darkish colored near the ground, dull gray above and grayish-brown among the branches, where it is quite smooth and but little furrowed. It is coarsely cellular, dull red within, with a thin band of yellow or yellowish bark 1–2^{mm} thick next the wood. The smaller branches are lustrous, the older being green tinged with red. Those of the second year are greenish-brown to olivaceous, those of the year brown to reddish-brown, both often mottled with spots or areas of gray. The younger are well furnished with small, grayish, oblong or roundish, raised lenticels. The winter buds are 4–8^{mm} long, ovate, obtuse or acutish, sometimes slightly angled. The scales are ovate to oval, ciliolate, the outer brown to reddish-brown, with a rusty or grayish pubescence, the apex blunt or rounded. The unfolding leaves are spreading or a little drooping, often slightly tinged with red, densely covered with white tomentum, giving the foliage a silvery-gray appearance. The stipules are 12–15^{mm} long, scarious or membranaceous, caducous, oblanceolate-linear to linear, hairy on the margin and with a few scattered hairs on the surface. The leaves soon become smooth and lustrous green above, lighter green and smooth beneath or with slight tufts of pale hairs in the axils of the principal veins. They are from 6–15^{cm} long, 5–12^{cm} wide, oval-orbicular or somewhat obovate-orbicular in outline, the broadest part usually just above the middle, and are deeply cut into 5–7 lobes by broad sinuses rounded at the base which extend halfway or nearly to the midrib. The lobes are generally oblong, the terminal broader and somewhat quadrangular, their sides nearly parallel or a little diverging above the middle. They end in three to five triangular teeth with slender bristles. The base of the leaf is bluntly cuneate to truncate, the parenchyma on one side usually a little lower. The petioles are rather slender, 2.5–5^{cm} long (generally about 4^{cm}), usually tinged with red on the upper side. The color of the autumn leaves varies, but in most is yellowish to pale brown, more or less blotched or tinged with red or purple. Some change to a vinous or crimson purple, giving the tree a dark reddish appearance. In the winter they are pale brown.

The aments are in clusters, slender, 5–8^{cm} long, loosely flowered, puberulent, from lateral buds which after flowering may be prolonged into leafy shoots. The calyx is membranaceous, campanulate, usually tinged with vinous red, two to five-lobed, cleft, parted, or divided into oblong, oval, ovate or roundish segments, their shape depending on

the number and depth of the divisions. A frequent form of calyx is one divided to the base on the side next to the rachis, the margin two or three-lobed or parted. The segments are smooth or slightly scabrous with a few minute scattered hairs, the tips copiously fringed with long, flattish, twisted or curling hairs. Stamens four or five, about the length of the calyx lobes. Anthers longer than the filaments, oblong, with a cordate base and blunt or emarginate apex which is sometimes apiculate.

The pistillate flowers are from the axils of leaves on fresh shoots of the year, their peduncles stout and very tomentose, and one to three-flowered. The calyx is tubular campanulate, the upper part generally strongly tinged with vinous red, and is four to seven-lobed, cleft or parted, the margin laciniate hairy and fringed with usually long hairs. Styles three, spreading or recurved, thick and flattish, hairy near the base, the enlarged rounded or knoblike stigmas dark colored and slightly two-lobed. The involucral scales are hairy, commonly reddish, mostly broad and blunt-pointed. There is often a basal lanceolate and bract-like scale. The acorns are single or in pairs, the cup turbinate or cup-shaped, thinnish, covering one third to one half or more of the nut and commonly tapering into a peduncle 8–15^{mm} long. In some forms the cup is thickened near the margin, forming a kind of shoulder (*plate II, f*). The scales are narrow-ovate, obtuse or truncate, brownish, pubescent, closely appressed, sometimes a little loosened near the rim on drying. The margin is thin, hyaline, and slightly eroded. The cup within is puberulent, pale brown, the thin margin with a more deeply colored, reddish or yellowish ring. The nut is chestnut-brown, often striped with darker lines, puberulent, 12–20^{mm} long, 10–15^{mm} wide, ellipsoidal, varying from a cylindrical to a shorter somewhat globular form. The kernel is pale yellow and bitter, at least to the after taste.

Quercus ellipsoidalis more closely resembles *Q. palustris* in general appearance than the other common biennial oaks of the vicinity. There are also strong reminders of *Q. coccinea* and *Q. velutina*. It shares with *Q. palustris* a comparative smoothness of bark for an oak, the depressed lower limbs often coming low down on the trunk, the finely divided leaves and the general character of its branching, but the lobation of the leaves, the inner bark, and especially the acorns, are different. It has the smoothest bark of any except this and young boles of *Q. rubra*, which it also resembles in the smoothness and color of the

trunk after branching, as well as the larger branches themselves, in these characters. The smaller lower branches readily die off like those of *Q. palustris* but do not leave the prominent stubs so characteristic of the pin oak. The tinge of dark color low down on the trunk, the thin layer of yellow bark next to the wood, the coarse-grained wood itself, the presence of hairs in the axils of the veins of the leaf, the relatively dull color of the autumn leaves, suggest *Q. velutina*, but it does not have the roughness and blackness of bark which the black oak shows very early in its growth; there is much less yellow in the bark itself, and it has an acorn different in form and very unlike in the scales of the cup.

When first observed in the fall of 1891, with some misgivings it was called *Q. coccinea*, partly on account of the acorns, which in general appearance are more like some forms of fruit in this species, and partly on account of a tendency to red, of a purple or crimson cast, however, seen in some of the autumn leaves. Its leaves also divide more like those of *Q. coccinea* and it has the reddish tinge of the inner bark, but the leaves do not turn scarlet in autumn, the outer bark is darker colored and much less rough and broken than on boles of *Q. coccinea* of similar age or size. It is also far less lichen-covered than trunks of *Q. coccinea* (generally it is comparatively free from lichens), for the scarlet oak seems preeminently chosen among the black oaks by these plants, which sometimes are so close and large as nearly to conceal the color of the bark and at once reveal its specific character.

Hybridity was thought of and was suggested by others; a cross between *Q. coccinea* and *velutina*, though *palustris* might almost as well be added. But the trees are too numerous to resort to this explanation, even if they had such an origin, which I regard as possible or even probable for species. South of the Calumet river near Halsted street it spreads over an area of several acres, and is equally common south of Glenwood in this county. In the first locality it gives place eastward to *Q. rubra;* in the second it is more commonly associated with *velutina* and *coccinea*. Where first found, at Gardner's Park near the southern limits of Chicago, it also grows with *Q. velutina*, and *rubra* is near by. The soil in this place is sandy, an ancient beach of Lake Michigan, very thin and overlying a heavy clay. Elsewhere it grows in clay soil. Aside from these three localities, that of Glenwood extending northward with scattered trees or areas toward Thornton, I have not detected it elsewhere. But acorns from trees which unfortu-

nately were cut down before they could be fully studied suggest its presence north of the city in the vicinity of Winnetka.

That it differs from the ordinary black oaks to the eye of other than botanical observers is evident from the fact that an intelligent farmer had separated it from its congeners, calling it "yellow oak," and remarking the tendency of the lower limbs to die. No chestnut oaks, to which this name commonly applies, grew there, so that it could in no way be confounded with this, even if the leaves were not so different. Looked at in the summer it gives the impression of great leafiness, the leaves being small as a whole, and of airiness on account of its glossy and finely divided leaves. In the winter it impresses by the glitter of its smooth bright branches when free from leaves, and by its great twigginess, due to the spray repeatedly and finely dividing, forming an irregular network as one looks through it.

As the form of the acorns first suggested specific difference, and on the whole is the most constant characteristic, the name *Quercus ellipsoidalis* seems most appropriate.—E. J. HILL, *Chicago, Ill.*

EXPLANATION OF PLATES II AND III.

PLATE II.—*Quercus ellipsoidalis* Hill.—*a*, Flowering branch, natural size; *b*, staminate flower, enlarged nine diameters; *c*, pistillate flower, enlarged nine diameters; *d* leaf, natural size; *e*, *f*, acorns, natural size.

PLATE III.—*Quercus ellipsoidalis* Hill.—*a*, Fruiting branch, five sixths natural size; *b*, nut, natural size; *c*, vertical section of nut, natural size; *d*, seed, natural size; *e*, winter branchlet.

THE WYOMING SPECIES OF ANTENNARIA.

MOST valuable and efficient work has been done recently by Drs. Greene[1] and Rydberg[2] in the long neglected genus Antennaria. A critical examination of the material in the Herbarium of the University of Wyoming in the light of these contributions has led to the discovery of a few forms, hitherto undescribed, which seem worthy of specific rank. It has seemed well, also, to make mention of all Wyoming species of which specimens are at hand.

Antennaria reflexa, n. sp.—Low and cespitose, somewhat subligneous at base, with very short leafy offsets: stems 5–10^{cm} high: leaves

[1] Pittonia 3: 172, 273, 289.

[2] Bull. Torr. Bot. Club 24: 299.

HILL on a NEW OAK.

HILL on a NEW OAK.

spatulate-obovate or spatulate, obtuse to acutish, about 1^{cm} long, rarely more, densely tomentose on both sides; cauline leaves narrowly oblong, obtusish to acute: heads very small, about 4^{mm} high, sessile, 3 to 8 in a close glomerate cluster: involucres very woolly, in the pistillate heads campanulate-cylindrical; bracts of pistillate heads narrow, the inner acute, the scarious portion dark greenish-brown, the outer much shorter, broader, woolly to the tip or almost so; in the staminate heads the scarious portion also dark greenish-brown, oblong-obovate, very obtuse, spreading and becoming reflexed with age: pappus of staminate heads clavellate.

This species differs from all other related forms in that the short outer bracts are woolly to the tip. From *A. umbrinella*, its nearest relative, it differs in its much darker bracts, and acute pistillate ones. It inhabits dry open hillsides at subalpine stations.

Type, no. 1265, in Herb. Univ. of Wyo., from Centennial valley, June 9, 1895; also no. 853, Union Pass, Wind River mountains, Aug. 11, 1894 (both by *Aven Nelson*).

Antennaria mucronata, n. sp.— Loosely cespitose: stems $5–12^{cm}$ high; stolons sparingly leafy, at most 4^{cm} long: leaves oblanceolate or narrowly spatulate, the mucronate tip usually hidden by the tomentum, 2^{cm} long, $3–5^{mm}$ broad, both faces densely woolly-tomentose varying to sparse and hoary, only the lowest on the stolons becoming glabrate; these when glabrate equally so on both sides, with a prominent midrib beneath and an obvious mucronate tip; cauline leaves oblong-linear, acuminate: heads in a subcapitate cluster, sessile or pedicels very short, the lowest occasionally with a pedicel as long as the head: involucres woolly at base; bracts (pistillate) oblong-lanceolate, 5^{mm} long, the obtusish tips usually erose, the scarious portion dark greenish-brown or dark brown, rarely with a white tip.

A very distinct species, from the alpine summits of southeastern Wyoming. From *A. umbrinella* it differs in its longer oblanceolate leaves, its much darker greenish pistillate bracts, and its lighter tomentum. It is probably more nearly related to *A. media*, but its affinities with that species I have not been able to settle, there being no description of the latter.

Type, no. 5211, in Herb. Univ. of Wyo. from La Plata mines in the Medicine Bow mountains, Aug. 28, 1898; also by *Aven Nelson*, no. 4227, Battle ake in the Sierra Madre mountains, Aug. 17, 1897.

ANTENNARIA UMBRINELLA Rydb., Bull. Torr. Bot. Club **24**: 302.— This species is represented by only one specimen in this herbarium,

collected by Aven Nelson at the head of Green river, Aug. 14, 1894, no. 885. This is far from being typical. The leaves are narrowly oblanceolate, and the pistillate bracts are hardly obtuse. More material of this might prove it to be entirely distinct.

ANTENNARIA APRICA Greene, Pitt. **3**: 274.—This excellent species is common in the foothills of the Laramie and Medicine Bow mountains, flowering early in the spring on sunny slopes. Many of our specimens have pinkish bracts (pistillate), and often as many as 14 heads in a cluster. The following are the specimens in the herbarium: no. 1269, Centennial valley, June 9, 1895; no. 149, Pole creek, June 3, 1894; Inyan Kara divide Aug. 29, 1892 (*B. C. Buffum*); no. 4347, Plumbago cañon, June 9, 1898.

Antennaria arida, n. sp.— Cespitose, in dense mats formed by the numerous short (1^{cm} high) ascending sterile branches: stems $10–15^{cm}$ high, slender, wiry, weak above, the subcapitate cluster frequently nodding, loosely covered with shreddy wool: leaves crowded, spatulate, acutish, $0.8–1^{cm}$ long, densely and permanently hoary tomentose on both sides, inclined to be conduplicate and noticeably so in the younger leaves; cauline leaves oblong linear, acute, lightly hoary-tomentose, more or less twisted and curved: heads 6^{mm} high, sessile, 6–10 in a subcapitate cluster: involucres turbinate; bracts (pistillate) in about two series, all obtuse, scarious portion oblong, milk-white, occasionally the outer with a purplish streak.

A remarkably distinct species, from the arid region of southwestern Wyoming. Type in Herb. Univ. of Wyo., no. 4798, collected by *Aven Nelson* at Tipton, June 17, 1898.

Antennaria scariosa, n. sp.— Cespitose, lightly hoary tomentose throughout: stems $3–6^{cm}$ high; stolons short, at most 4^{cm} long: leaves 1.4^{cm} long or less, spatulate, obtuse or acutish, inclined to be conduplicate; cauline leaves rather ample, oblanceolate varying to narrowly oblong, occasionally the lowest spatulate: heads 6^{mm} high, sessile, 6–8 in a subcapitate leafy-bracted cluster: bracts (pistillate) rather conspicuously scarious, all obtuse, the scarious portion milk-white elliptic to obovate.

In its floral character this is very closely allied to *A. arida*, differing only in its broader bracts. *A. scariosa* differs from that species, also, in its smaller size, its more prostrate habit, its larger radical leaves, and in its more ample cauline ones, which are never twisted. It also seems to be related to

A. recurva, as is evident from Dr. Greene's description of that species. It cannot be that species, however, for *A. scariosa* is distinctly cespitose, much resembling *A. aprica* in that respect, and its bracts (pistillate) are decidedly obtuse. Its leaves are also smaller and its stems taller.

Type in Herb. Univ. of Wyo., no. 4587, Leroy, Uinta co., June 7, 1898, by *Aven Nelson*.

ANTENNARIA ROSEA (Eat.) Greene, Pitt. **3**: 281.— Of this beautiful species there is but one specimen in this collection, secured by Aven Nelson at Dome lake, near the summit of the Big Horn mountains, July 16, 1896, no. 2904.

ANTENNARIA PARVIFOLIA Nutt., Trans. Phil. Soc. **7**: 408. *Antennaria microphylla* Rydb., Bull. Torr. Bot. Club. **24**: 303.— This is our commonest Antennaria, met with everywhere in meadows on the high elevated plains of Wyoming. Its distinctive characters have been already pointed out by Dr. Greene. However, from an examination of our rather numerous specimens of this species, the following characters are noticeable. The exceedingly small leaves are covered with a dense lustrous silvery tomentum, and the apices are triangular. The subtending bracts and the one or two uppermost cauline leaves are inclined to be glabrate, and somewhat viscid-glandular. The stems are usually covered with floccose wool. In none of our specimens is there any trace of a pinkish tinge in the pistillate bracts. A dwarf form (no. 3578) with very broad truncate-obtuse staminate bracts, from southwestern Wyoming, is probably very nearly typical. The following are the chief collections of this species: no. 762, Upper Wind river, August 10, 1894; no. 762, Dubois, August 10, 1894; no. 3514, Pine Bluffs, July 6, 1897; no. 3578, North Vermillion creek, July 17, 1897; no. 4846, Freezeout hills, July 10, 1898; no. 4933, Seminole mountains, July 21, 1898; also, by *Miss Clara Sanders* from Little Goose creek, Sheridan county.

Antennaria imbricata, n. sp.— Stems about 30^{cm} high, inclined to be wavy; stolons very short: leaves spatulate, mucronate, 1-nerved, 2^{cm} long, lightly tomentose on both sides; cauline leaves hoary pubescent, clasping, longer but not broader than those of the stolons, oblong-linear, the margins frequently undulately revolute, the lower slightly broadened upwards, somewhat obtusish and mucronate, the upper narrowed upwards and acute: heads large, about 7^{mm} high, in a close cluster; the pedicels very short, covered with yellowish wool as also

the base of the involucres: bracts (pistillate) imbricated, in about four series, pinkish, all more or less serrulate, the outer very broad and obtuse, the innermost narrow and acute.

It differs from *A. parvifolia* in its larger, less silvery leaves, and in its much broader pistillate bracts. From *A. foliacea* it is readily distinguished by its less ample cauline leaves, its much larger heads and its pluriserial bracts.

Type in Herb. Univ. of Wyo., no. 2036, collected in a meadow on North fork of Crow creek in the Laramie hills, July 11, 1896 (*Elias Nelson*).

Antennaria corymbosa, n. sp.— Stems erect, 25^{cm} high, with numerous ascending or assurgent sterile branches at base: leaves thin, sparsely tomentose, 1-nerved or indistinctly 3-nerved, narrowly oblanceolate, tapering gradually into a slender petiole, 3–3.5^{cm} long (including petiole); cauline leaves shorter, linear, acuminate: heads small, 4–5^{mm} high, in a rather close corymbose cyme, the lowest pedicel usually surpassing the others in length: involucres woolly with cobwebby hairs; bracts (pistillate) in about three series, oblanceolate, obtuse or the innermost acutish, a brown spot above the greenish portion, tips white.

A well marked species, evidently closely related to *A. pedicellata,* from which it differs in its obviously nerved and much less conspicuous leaves. Its woolly, cobwebby involucres and the brown middle portion of its bracts give a characteristic appearance.

Type in Herb. Univ. of Wyo., no. 4160, collected by *Aven Nelson* on a sunny slope at Battle lake in the Sierra Madre mountains, August 15, 1897.

ANTENNARIA RACEMOSA Hook, Fl. Bor. Am 1:330.— This well-known species was collected by Aven Nelson in 1894, Union pass, August 1, no. 812.

ANTENNARIA PULCHERRIMA (Hook.) Greene, Pitt. 3:176.— This is common at subalpine stations, growing in rich, loamy soil on wooded hillsides, no. 819, Union pass, August 12, 1894; no. 3225, Green top, June 28, 1897.— ELIAS NELSON, *University of Wyoming, Laramie.*

A NEW COLORADO ANTENNARIA.

THROUGH the kindness of Professor C. S. Crandall it has been possible to examine the specimens of Antennaria in the Herbarium of the Agricultural College of Colorado. This has brought to light a member of the *A. plantaginifolia* group which has not as yet been

recognized. Since *A. plantaginifolia* has at last been broken up into well defined species, this one, which offers excellent points of distinction, may be named

Antennaria obovata, n. sp.— Stems 30^{cm} high: stolons 5–8^{cm} long, with very small leaves and only properly leafy terminally: leaves all of firm texture, permanently tomentose on both sides, the tomentum even persisting on the dry leaves of the preceding year; the basal 3^{cm} long, 3-ribbed, the prominent midrib continuous to the apex, the two lateral ones becoming evanescent toward the margin, the blade obovate-cuneate, about 13^{mm} broad, a little longer than the ligulate petiole; the terminal ones of the stolons 25^{mm} long, less distinctly 3-ribbed: cauline leaves small, oblong-linear: heads 3–7, corymbosely disposed on pedicels 5–20^{mm} long: involucres sparingly long woolly: bracts (pistillate) in several series; the outer short and obtusish; the inner twice as long, narrow, acute to acuminate; nearly all with a purplish spot at the middle: akenes oblong-fusiform, indistinctly 5-angled, papillose.

To what is now considered as *A. plantaginifolia* it bears little resemblance, being perhaps more widely separated from that than any of the recently described species of that group. It is from the foothills of Colorado; collected by J. H. Cowan, near Soldier cañon, June 20, 1895.—Elias Nelson, *University of Wyoming, Laramie.*

CURRENT LITERATURE.

BOOK REVIEWS.

A new treatise on ecology.

THE impetus to a study of ecology as an integral part of botany, coordinate with morphology and physiology, dates back to Warming's *Ecological plant geography*, published only four years ago.[1] The rapidity with which this new field of study is developing is shown by the large number of special treatises which have appeared since Warming's work. This latest work of Schimper[2] is calculated to lead another great advance, and may be said probably to mark the beginning of a second epoch in the pursuit of ecological investigation.

Schimper, like Warming, is not a narrow specialist, but has made valuable additions to our knowledge in many fields of botanical research. His studies in morphology, cytology, physiology, taxonomy, and ecology have peculiarly fitted him to take up an immense work of this sort in a thoroughly scientific manner. The result of his labors is a volume of nearly 900 pages, a veritable compendium of ecological knowledge, systematized and brought up to date. In the preface the author says that the cue for ecological study was given by the study of plants in extreme conditions, since only there are the effects of environment strongly marked and easily understood. Hence investigations in the tropics, and above all the studies of Haberlandt, Wiesner, and others at Buitenzorg, have given a great impetus to the study of ecology. Schimper appeals for a polar laboratory, so as to study the extreme but relatively simple effects of an arctic environment.

The general divisions of Schimper's *Plant geography* resemble those of Warming. First, the ecological factors are treated; water, heat, light, air, soil, animals. Then there is a discussion of formations and associations in general. Over three fourths of the work is taken up with a detailed description of the formations of the various zones and regions, the tropical, temperate, and arctic zones, the mountains and the waters.

[1] WARMING, EUGEN: Plantesamfund. Grundträk af den ökologiske Plantegeografi. Kjöbenhavn. 1895. See BOT. GAZ. **22**: 173. 1896.

[2] SCHIMPER, A. F. W.: Pflanzengeographie auf physiologischer Grundlage. Mit 502 als Tafeln oder in den Text gedruckten Abbildungen in Autotypie, 5 Tafeln in Lichtdruck und 4 geographischen Karten. 8vo. pp. xviii + 876. Jena: Gustav Fischer. 1898. Brosch. *M* 27; geb. *M* 30.

There are several general features in the work which strike one at a glance, and which are highly commendable. There is a wealth of well-chosen illustrations of plant habits and plant formations, largely reproductions of photographs. These pictures are thoroughly representative, and illustrate the leading features of all regions thus far studied. A second highly commendable feature is the persistent correlation of ecological observations on plants in the field with physiological experiments carried on in the same region. Observation and experiment together check erroneous conclusions derived from one alone. Meteorological data and anatomical study also contribute their part to the interpretation of the facts of observation. In every case, Schimper has brought all possible data together in a more systematic and thorough manner than has been previously attempted. Hence, the probability that his conclusions are correct is very great. The bibliographies are remarkably complete and easy to consult because of their topical arrangement.

Another characteristic that will be pleasing to botanists everywhere is the absence of any undue predilection for Germany and German botanists. The work of botanists all over the world is given a proper share of attention. It is gratifying, too, to see the wealth of material furnished from tropical fields, and largely by the author himself. The use of the word ecology in place of biology is a pleasing departure and a deserved tribute to Warming.

Among the new points of view that are presented is Schimper's statement of the relation between plants and water. Hygrophytes are plants that further their transpiration, xerophytes are plants that check it, while the word tropophyte is introduced to include those plants which are hygrophytic at one season and xerophytic at another. According to this view, these terms are placed on a physiological rather than a physical basis. The plant itself, rather than the soil in which it grows, is called hygrophytic or xerophytic.

Another striking difference from Warming is seen in considering various ecological agents equivalent with water as factors in classification. Thus the simplicity of Warming's classification is replaced by a much greater complexity. This is the common fate of all sciences, as is well illustrated by a comparison of the simple taxonomic system of Linnæus with that of Engler. The great zones of the earth are determined primarily by the distribution of heat, while the great formations of these zones, such as forest, savanna, or desert, are determined chiefly by meteoric water. The local diversities in these great regions are said to be caused by differences in the soil. Thus we have two great types of formations: (1) climatic formations which characterize great regions and are caused by climatic factors, and (2) edaphic (from ἔδαφος, soil) formations, which make up the local variations in any district and are due to a local dominance of edaphic over climatic influences. Schimper also lays much greater stress than does Warming upon the

influence of light, heat, atmospheric density, and the chemical nature of the soil, in shaping the character of the vegetation.

It seems unfortunate to the reviewer that more attention was not paid to what may be called, speaking broadly, the geological relation. The short section on the transformation of edaphic to climatic formations is excellent and might well be much enlarged. In order to understand any formation it is necessary to know its history, and this history can be interpreted only by the most painstaking study of areas in which transitions from edaphic to climatic formations are now taking place. With this study there must be coupled a study of the physiographic history of the region. The study of the cumulative influence of past environments, the lagging of effects behind their causes, is still in its infancy. Perhaps it is because of our lack of knowledge along these lines that Schimper's great work deals so much more with static than with developmental ecology.

This new treatise is a distinct addition to our knowledge, both as a compendium of previously stated but scattered facts, and as a source of many new details and better points of view. Of course all ecologists must have it and must be familiar with its contents from cover to cover. This new volume is certain to stand always as one of the great botanical masterpieces. — HENRY C. COWLES.

Economic botany.

ONE of the best works yet written upon cultivated plants has just been published by Dr. R. Sadebeck.[3] While the title might suggest that the subject matter would attract only those especially interested in the plants of the German colonies, this is not at all true, since these plants are discussed so comprehensively that their relations to dissimilar as well as similar economic plants of other regions are constantly suggested. After having given a careful description of the taxonomic features of a plant, the author discusses its culture, its native region and its distribution, the varieties produced under cultivation, its useful products and the way in which these are utilized as foods, medicines, or in industrial arts. Photographs and drawings, almost all of which were especially made to illustrate this work, appear in abundance. These illustrations, while having to do almost entirely with taxonomic features, are so excellent that they constitute one of the most pleasing and satisfactory parts of the book.

In the first chapter the author discusses the palms. At least thirteen genera are grown in the African colonies, producing large quantities of food material for local consumption and for commerce. Several of these also supply important textile materials and all are prominent features of the landscape. Another chapter is devoted to the description, cultivation, and

[3] SADEBECK, R.: Die Kulturgewächse der deutschen Kolonien und ihre Erzeugnisse. 8vo. pp. xiii + 366. *figs. 127*. Jena: Gustav Fischer. 1898, Brosch. *M* 10; geb. *M* 11.

preparation of tobacco for use. This is the most widely cultivated plant of the German colonies, being grown everywhere. Only the species *N. Tabacum* is extensively grown, *N. rustica*, which is so common in some other tropical countries, being scarcely known. The fungus parasites which induce diseases of this plant are numerous, and the way in which they affect the plant is equally varied. At the close of this chapter is appended a bibliography of the most important literature upon the subject. Many readers will regret that a similar appendix is not to be found with the other subjects.

The other twelve chapters of the book are not arranged with reference to any particular genus or group of plants, but with reference to certain economic products, as "Grains and sugars," "Edible fruits and vegetables," and "Eigentliche Genussmittel"—the coffee and tea group. The colonies produce many of the spices, and the number of plants yielding fats and oils is no less. Indigo, gums, caoutchouc, and gutta-percha are prominent among the products of the colonies. Twenty plants yield textile materials or useful woods. The number of medicinal plants grown is very small, and comparatively little space is given to the chapter which deals with these.

It is obviously the author's intention to deal merely with that part of economic botany which has to do with the useful plants; and those unfamiliar with this subject will be surprised to find that there are so many of these. Dr. Sadebeck expresses the belief that should the people of the German colonies, through the medium of such a book as he has written, become informed of the possibilities, the product from these plants, at present not large, would be very greatly increased. A comparison of the unused regions with those in which these plants are now grown shows that the cultivation has scarcely begun. The book is full of information and is worthy of the attention of every one interested in the inter-relationships of men and plants.—OTIS W CALDWELL.

The making of a daisy.[4]

TO POPULARIZE science is a worthy purpose, and it should be undertaken more by those who represent it. As the reviewer understands it, to popularize is to present the important facts in simple language, free from technicalities and with clear illustrations, in an attractive style, but never at the expense of accuracy. Judged by such a definition the book before us cannot be called a success, but it is a good type of its class. The author is well informed, but her contact with plants seems to be sentimental rather than scientific. To cultivate a sentimental affection for nature is delightful, but it should never be labeled science.

Certain facts about plants are taken, and most fanciful, not to say dreamy,

[4] HUGHES-GIBB, ELEANOR: The making of a daisy; "wheat out of lilies;" and other studies in plant-life and evolution. A popular introduction to botany. 8vo. pp. 126. Charles Griffin & Co.: London, 1898.

hypotheses are developed. For example, "the making of a daisy" is presented as "a study in evolution," and the processes involved, from "the beautiful, flowerless fern-trees and gigantic mosses," where "the arrangements for reproduction are so complicated that it is almost impossible for any person to understand them" (as presumably they do in seed plants), to the daisy, are something that would amaze the morphologist. "Looking carefully amongst the fronds of some palm-like fern," the author fancies that she "might have discovered two small objects," "the one had a yellow, powdery head, whilst the surface of the other was more or less sticky." These "small objects" discovered in imagination on an ancient tree fern are "a single stamen and a single naked ovule," the "first parents of the flowers." It is this sort of wild imagination that seems to the reviewer to do more harm than good.

There is a constant outcry throughout the book against the "hard words" of the science, but in the chapter on the "relationship of the flowers," the pages fairly bristle with the old morphology in reference to "cohesion," "adhesion," "suppression," etc., and such group names as "Dichlamydeæ," "Thalamifloræ," "Calycifloræ," etc.

It should be understood that the reviewer makes no objection to the book as a piece of sentimental literature, but as "a popular introduction to botany" he must protest against it.— J. M. C.

California plants.[5]

MRS. DAVIDSON has certainly done good service for nature study in southern California, and has given a model for similar books in other regions. She does not seek to arouse a factitious interest in plants by "fairy tales," but in a very attractive style tells of the most evident things that can be observed. The book cannot be used without a study of the living plants, in cultivation or in the field, which is much in its favor. It is a storehouse of suggested observations when in contact with the material. And the material selected is what the author has found to be most available in her long experience in southern California. "The aim is to awaken interest in common plants, and to invest them with new meaning. Pond-scums, mould, and toadstools are included among these familiar plants, and sea-mosses, lichens, and ferns are believed to be as attractive as flowering plants."

A voluminous supplement takes up each chapter and gives full suggestions to teachers. Evidently the author's experience has shown to her how much they need it. It is a pleasure to commend a book prepared for nature study, a book which does not leave its few facts to spin out endless fancies, but which goes directly and soberly out among the plants of the neighborhood and calls attention to what can be observed.— J. M. C.

[5] DAVIDSON, ALICE MERRITT: California plants in their homes. A botanical reader for children. 8vo. pp. 133. B. R. Baumgardt & Co.: Los Angeles, Cal., 1898.

The evolution of plants.[6]

BOOKS of this kind are exceedingly useful, and there should be more of them. It is hard for one who is not a professional botanist to get from ordinary text-books much idea of the evolution of plants as a whole. The worst of it is that those who know little or nothing of modern morphology have written most in a popular way about the evolution of plants, and have propagated fanciful notions which are hard to eradicate.

The basis of this little volume is a course of lectures given at Stanford University, and its purpose is to organize well-known botanical material to illustrate the probable lines of evolution. The book will demand some elementary knowledge of plant groups, but it is probably as simple as the subject will permit. There is no presentation of new theories or discussion of old ones for the benefit of the professional botanist, but merely a statement of current views. Undoubtedly exception will be taken to certain views of homology and phylogeny, but this is to be expected whenever difference of opinion is possible.

It is of interest to the professional botanist to note the author's opinions as to phylogeny, many of them of course very cautiously expressed. Leaving aside the myxomycete and schizophyte forms as altogether problematical, the green algæ, considered the most primitive of the three classes of algæ, are regarded as having arisen probably from simple Volvox-like types, the Volvox, Protococcus, and Conferva forms representing a continuous series leading to the higher plants. From this stock the Siphoneæ, Conjugatæ, Rhodophyceæ, and possibly the Characeæ, have arisen as offshoots. It is suggested that the brown algæ may have had an independent origin. The origin of the liverworts from the green algæ, and that of the pteridophytes from Anthoceros-like liverworts is still maintained. In reference to the seed plants, the conifers are regarded as phylogenetically related to the club-mosses; while the cycads and angiosperms are referred to the ferns. Two lines of dicotyls are represented as having arisen from the monocotyls, one from the aroid forms, leading through peppers to amentaceous and isocarpous sympetalous forms; the other from apocarpous monocotyls and leading to the anisocarpous sympetalous forms, and culminating in the Compositæ.

The book is full of interest and suggestion, and commends itself not only to those who wish a reading knowledge of botany, but also to teachers of botany.—J. M. C.

[6] CAMPBELL, DOUGLAS HOUGHTON: Lectures on the evolution of plants. 8vo. pp. viii + 319. The Macmillan Company: New York. 1899. $1.25.

MINOR NOTICES.

DR. H. E. HASSE has issued a second edition of his *Lichens of Southern California*. It is reprinted, and unfortunately repaged, from the *Proceedings* of the Southern California Academy. When will authors and publishers learn that a repaged separate is thereby mischievously removed from its proper place in literature and made a source of annoyance whenever occasion arises for citing it? The list itself is useful and the work praiseworthy.—C. R. B.

THE SECOND FASCICLE[7] of Dr. M. Gürke's continuation of Richter's *Plantæ Europææ* has just appeared. The first fascicle has been reviewed in this journal (**24**: 122. 1897), and no further explanation is needed as to the occasion and method of the work. The first fascicle presented the Archichlamydeæ from Juglandaceæ to Chenopodiaceæ; the present fascicle continues through Caryophyllaceæ, in fact most of the fascicle is given to this family.—J. M. C.

THE DEPARTMENT OF AGRICULTURE is prompt to take charge of our new domain. Hardly had Hawaii and Puerto Rico come into the possession of the United States before a bulletin (no. 21) on vanilla culture appeared from the Division of Botany, prepared by S. J. Galbraith, a planter in the Seychelles islands, where vanilla is extensively cultivated. It is hoped that both Hawaii and Puerto Rico will be found to furnish suitable conditions for this profitable industry, but warning is given that a very destructive parasitic fungus may accompany the introduced plants unless carefully examined by an expert.—J. M. C.

THE WRITINGS of Professor Beal are well known, and also the service he has rendered to the teaching of botany. His recent little book, entitled "Seed Dispersal,"[8] is intended to help "young botanists and teachers," and deals with one of the most attractive of botanical subjects. The title is a little misleading, as the book takes a wider range than seed dispersal. For example, vegetative propagation, spore dispersal, and plant migration are all discussed. The author writes in a pleasant, conversational style, and the book should serve its purpose well. The sketches are original, and deal with common plants.—J. M. C.

[7] GÜRKE, DR. M. Plantæ Europææ. Enumeratio systematica et synonymica plantarum phanerogamicarum in Europa sponte crescentium vel mere inquilinarum. Operis a Dr. K. Richter incepti. Tomus II. Fasc. ii. 8vo. pp. 161–320. Leipzig: Wilhelm Engelmann, 1899. *M* 5.

[8] BEAL, W. J. Seed dispersal. 8vo. pp. vii + 87. Ginn & Co. Boston. 1898.

NOTES FOR STUDENTS.

[At the request of the editors Dr. Otto Kuntze has kindly prepared the following brief synopsis of his most recent volume.[9]— EDITORS.]

THE FIRST PAGES (1–384) in the body of the work contain the list of plants collected in Patagonia, Argentine, Chili, Bolivia, Paraguay, Brazil, and also during the author's travels in South Africa. There are described 11 new genera, 18 new subgenera, 566 new species, and more than 600 new varieties. The minor part of the collections was studied by thirty-two collaborators, and 6 new genera and 179 new species have been previously published.

The change in the generic names of phanerogams, according to the Paris Code, are very few, as they were revised in 1891 in volumes I and II.

For the algæ, however, a change of 36 generic names is proposed, and those made in 1891 are mostly defended against the criticisms of M. Le Jolis, who has opposed with the following ideas: (1) that priority be not retroactive; but the Paris Code excludes only names before Linnaeus; (2) that adjectives cannot be used for generic names; but hundreds of such names already exist; (3) that unfit names be rejected; but A. de Candolle has already written "un nom est un nom," and a name needs no meaning at all; (4) that an author be allowed to change his first definition of a genus and its name; but according to § 59 and its official commentary the first definition cannot be annulled; (5) he confounds obligatory and optional articles of the Code; (6) he rejects orthographical license and corrections, although allowed by the Code; (7) he allows only diagnoses for genera to be valid, against § 42 of the Code. His follower, M. Malinvaud, secretary of the Société botanique de France, has failed to make the necessary preparation for a Paris Congress in 1900 to amend the Paris Code of 1867.

As to fungi, I had shown formerly that in Saccardo's *Sylloge* 570 names of genera are entirely omitted. In proving them I have been compelled to renew 111 more generic names in *Revisio* III[ii] than in *Revisio* I and II. I also show that it is impossible to begin the nomenclature of fungi with a later starting point.

In pp. 1–202 of the Introduction I trace the movement in nomenclature from 1893 to 1898, but can report little of it here. However, some American positions may be mentioned. There are now two extreme parties of botanical systematists in the United States.

1. *The old party*, represented by Dr. Robinson, etc., follows no real principle at all, and has only one rule for genera.

"Long established and generally known generic names, such as Liatris, Desmodium, Dalea, Calycanthus, Carya, Aspidium, and others should be

[9] KUNTZE, OTTO: Revisio generum, etc., III[ii]. 8vo. pp. 784. New York: G. E. Stechert. September 1898. $7.

retained. While the scope of this rule is left to the discretion of writers, it is urged that generic nomenclature should not at present depart far from that of the three important works, Bentham and Hooker's *Genera Plantarum;* Baillon's *Histoire des Plantes*, and Engler and Prantl's *Natürliche Pflanzenfamilien*, from which for some time to come our most complete and accurate information as to generic limits and affinities is to be derived."

I have answered this in *Revisio* III[II] as follows: A rule which is left to the discretion of any botanist is no rule at all. The differences between (1) Baillon's *Histoire des Plantes*, who after 1891 accepted 70 per cent. of my nomenclature, reformed according to the Paris Code; (2) Bentham and Hooker's *Genera Plantarum;* (3) the disorderly nomenclature in 10 volumes of Engler and Prantl's *Pflanzenfamilien* by 62 collaborators; and (4) Engler's Supplementary nomenclature, corrected according to his rules, illustrate without further discussion the results of the method suggested. The numerous differences in nomenclature can only be removed by fixed rules, which are also necessary in consequence of the complications arising from competing generic homonyms. Order in nomenclature can only be restored by a consistent application of the rules of the Paris Code, which were adopted by the only international convention that has been held.

2. *The Check List party*, led by Professor Britton and others, with three very wrong principles: (1) 1753 as a starting point, (2) priority of place, (3) once a synonym, etc., applied retroactively.

The initial date, 1753, was originally a Kew proposition, and became fixed like the other "Kew rule," which allows the arbitrary rejection of the oldest specific name. This starting point was hastily adopted by the incompetent Genoa Congress which was "mal informe" as Professor Briquet wrote, who preferred the De Candollian starting point of 1737. It was only supposed, not proved, that 1753 is a rational starting point. But this date for genera is neither scientific, because 1753 is without genera diagnoses, nor is it economical. I have proved in *Revisio* III[ii], by a list of examples, that 129 more genera and 7100 more species are to be named with 1753 as a starting point than with 1737. Only 29 of these genera and 152 of these species have been named until now, although I had given in 1893 (*Revisio* III[I]) a similar list. That the 1753 rule should be abandoned is effectively shown by the fact that according to it about 100 genera and 6000 species still await renaming. I have also given a list of 64 genera which must be renamed according to either starting point, and another list of 46 other generic names which would be substituted for without profit. Formerly, I called 1753 for genera "initium ignorantium," but now, since its eminent harmfulness has been demonstrated, it becomes the "initium stupidorum" for those who maintain it and are not able to prove the contrary.

The priority of place principle has been applied until now to only 7

genera containing 74 named species, as against its abandonment for 23 genera containing 7310 species. This principle was applied in the manuscript of the Torrey *Check List* and sanctioned at the Madison meeting of 1893, five days before the Madison Botanical Congress. But in the *Check List*, as afterwards printed, this wrong principle was mostly eluded by separating in the Appendix, Blitum from Chenopodium, Sarothra from Hypericum, as also formerly Dalibarda from Rubus, Phaca from Astragalus, etc., to avoid the change of the thousands of specific names belonging to these genera. Thus the wrong principle was not applied, but resulted in bad taxonomy.

The principle "once a synonym always a synonym" was recommended by me only for future cases in which new names were necessary. If it is applied retroactively, however, it is very harmful, as I showed in 1894 in "nomenclatur Studien" (*Bull. Boiss.* 477–481), and now in *Revisio* III[II]. I show that with the retroactive use of this principle 447 generic names and 16,000 specific names of phanerogams are still to be changed; while only 34 generic and 134 specific names were changed until now by this principle. Since the harmfulness of the retroactive application is so evident, why not frankly abandon it?

Chapter 26 begins with the title "Engler's international breach of faith." He was the enterprising director of the deceased international commission of botanic nomenclature. He put aside the chairman of the commission, Professor P. Ascherson, in 1897, and with the aid of Professor K. Schumann produced fourteen new rules of nomenclature for his *Pflanzenfamilien*, baffling thereby any international congress, although under international obligation. Of these fourteen rules, thirteen were scarcely applicable and merely garniture to the second rule, which proposes to bar generic names that have not come into general use during fifty years, counting from their publication, unless they were taken up in a monograph or large flora, according to the laws of nomenclature of 1867. This ambiguous rule, of little profit, had already been declined in 1894 in Vienna by the Naturforscherversammlung, with the suggestion that it be approved by a competent congress. This rule was unfairly applied only in the supplement to Engler's *Pflanzenfamilien*, otherwise the editor would have been compelled to accept most of the reformed nomenclature of *Revisio* I and II. These fourteen rules were subscribed to by the officers of the Berlin Botanic Museum in a very careless manner, as is also shown by the "ich" of the editor, which "ich" remained uncorrected in these rules, although subscribed to by fourteen persons. They had never considered beforehand and together these rules, which have been also more or less declined by Professor Wettstein (Prag), Professor N. L. Britton (New York), Le Jolis (Cherbourg), Briquet (Geneva), James Britten (London), and E. Heirn, who has written in *Journal of Botany* (27: 494. 1898) that I criticised these rules in *Revisio* III[II] in a masterly way, and rejected the

second rule with powerful arguments. In a list (pp. 100–125) I show that 618 of my reformed generic names among the phanerogams, out of 740 in *Revisio* I and II, have been already accepted since 1891 by botanists all over the world, or that some of the names not yet accepted could not be rejected by the Berlin rules.

In pp. 40–42 I sum up the obscurities of the Kew Index. In chapter 31 I add further notes to Pritzel's *Thesaurus*, with exact dates for wrong or unknown dates of publication.

Since a competent international congress at Paris in 1900 is not possible, and the amendment of the Paris Code will scarcely be obtained for a long time, the only way to obtain international order in botanical nomenclature is by strictly following the Paris Code with my amendments, which are not at all revolutionary. But since the starting point 1735 has found everywhere least acceptance, it will be best to take the only really scientific and the most economical starting point of 1737. — DR. OTTO KUNTZE, *Villa Girola, San Remo, Italy.*

ITEMS OF TAXONOMIC INTEREST are as follows: A fascicle of eighteen new species of Lower Californian plants is published by T. S. BRANDEGEE in *Erythea* (7 : 1–9. 1899). — A new Botrychium from New England (*B. tenebrosum*) is published by A. A. EATON in *The Fern Bulletin* (7 : 7. 1899). — In the *Bull. Torr. Bot. Club* (25 : 605–621. 1898) JOHN K. SMALL continues his "Studies in the botany of the southeastern United States." Twenty-four new species are described as follows: Melanthium (1), Smilax (4), Gyrostachys (3), Oxalis (2), Physostegia (1), Euphorbia (4), Hypericum (1), Gaura (1), Verbena (1), Gerardia (2), Solidago (1), Doellingeria (1), Aster (1). The author's name *Forcipella* for a genus of the Paronychiaceæ having been preempted, he has replaced it by *Gibbesia*, in honor of Professor L. R. Gibbes, of Charleston, S. C. — In the same journal (626–629) A. A. HELLER publishes further notes concerning the plants of western North America. A new genus, *Fendlerella*, is proposed, established on *Fendlera* (§ FENDLERELLA) *Utahensis* Greene (*Whipplea Utahensis* Watson); and another new genus, *Macdougalia*, is established on *Actinella Bigelovii* Gray. — In the same journal (26 : 5–11. 1899) AVEN NELSON publishes ten new species of Wyoming plants in the following genera: Scirpus, Sagittaria, Lilium, Abronia, Arenaria, Aconitum, Astragalus (4 spp.). — H. NESS. in the same journal (26 : 21–22. *pl. 351.* 1899), describes a new Lacinaria (Liatris) from Texas. — E. L. GREENE has just published (*Pittonia* 4 : 1–24. 1899) four new species of Castilleia from the west, and a fascicle of seven new violets; has renamed *Viola bicolor* Pursh, calling it *V. Rafinesquii;* has described five new western roses, one of which (*R. pratinicola*) is the very common prairie form commonly referred to *R. Arkansana* or *R. blanda;* has established fourteen new species of western "choripetalous exogens" in the

following genera: Aquilegia, Ranunculus (2 spp.), Cleome, Draba (7 spp.) Thelypodium, Amelanchier (2 spp.); and has published notes on seven species of Machæranthera, two of which are new. — B. L. ROBINSON has described and figured (*Rhodora* **1**: 12. 1899) a new Lactuca (*L. Morssii*) from Massachusetts. — In Engler's *Bot. Jahrb.* (**25**: 578–708. 1898) F. REINECKE completes his account of the flora of the Samoan islands. In a previous paper (**23**: 237–368. 1896) the cryptogams were given; in this paper the "siphonogams" are presented, and also a complete species index to both papers. The total enumeration contains something over 1200 species, 141 of which are new. — In the same serial (709–721) R. PILGER describes thirty-one new species of South American (Columbia, Ecuador, Peru, and Bolivia) grasses, one of them representing a new genus, *Dasypoa*. — In the same serial (722–733) a series of papers upon the plants of Ecuador is begun, the families being assigned to different authors. Numerous new species are described, especially by K. Schumann, among the Asclepiadaceæ, six species being added to Cynanchum, and a new genus, *Anomotassa*, described. — In the same serial (**26**: 235–424. 1899) A. ENGLER continues the publication of the African flora. The Passifloraceæ, Araliaceæ, and Leguminosæ II (new genus *Fillæopsis*) are by H. Harms; Euphorbiaceæ IV (new genera *Crotonogynopsis* and *Tetracarpidium*) by F. Pax; Orchidaceæ by R. Schlechter; a new genus (*Megalochlamys*) of Acanthaceæ by G. Lindau; the African species of Brunnichia by U. Dammer; a new genus (*Charadrophila*) by R. Marloth, which possibly belongs to the Gesneriaceæ; Piperaceæ II by C. De Candolle; Piperaceæ III, Gesneriaceæ III (new genus *Carolofritschia*), Burseraceæ II (new genera *Canariastrum* and *Porphyranthus*), Rosaceæ II, Monimiaceæ (new genus *Chloropatane*), Lauraceæ (new genus *Tylostemon*), Menispermaceæ (new genera *Miersiophyton*, *Kolobopetalum*, *Syntriandrium*, *Limaciopsis*, and *Heptacyclum*), Araceæ II, all by A. ENGLER. — In the same serial P. GRAEBNER (425–436) discusses the South and Central American species of Valeriana, suggesting *Phaodendron* as a new section or possibly a new genus; and F. KRÄNZLIN (437–448) begins an account of the Orchidaceæ collected by Lehmann in Guatemala, Costa Rica, Columbia, and Ecuador. — MAXWELL T. MASTERS has determined (*Jour. Bot.* **37**: 1–11. 1899) that the juniper of Bermuda and that of Jamaica are specifically distinct, and that the latter is *J. Virginiana* L. (*J. Barbadensis* L. ex Griseb.), so extensively distributed throughout North America. The Bermudan plant (*J. Bermudiana*) is only known outside of Bermuda in cultivation, and seems to have been derived from the continental *J. Virginiana*. Why a form in Bermuda should have become specifically distinct, and one in Jamaica should have retained its specific characters, is an interesting question. — Another contribution to the African flora is a study of the genus *Boscia* by ANTON PESTALOZZI, being one of a series of papers published from the Botanical Museum of the Uni-

versity of Zürich. The taxonomic presentation is preceded by an excellent account of the morphology and anatomy of the genus. The twenty-nine species, five of which are new, are treated with remarkable fullness, an average of four pages being given to each one. Fourteen excellent lithographic plates, some of them colored, accompany the paper.— R. I. CRATTY in *Bull. Lab. Nat. Hist. Iowa* (4 : 313–375. *pls. 10.* 1898) has published a list of Iowa sedges, with synonymy and distribution. It contains 114 species and varieties, representing ten genera, Carex containing 78. Following the list are some interesting tables comparing the Iowa sedge flora with that of neighboring states.— W. N. SUKSDORF has published in *Deutsche bot. Monatsschrift* (16 : 220–222. 1898) an account of certain Washington species of Claytonia, which he refers to Montia and renames. — An enumeration of the species of plants collected by Dr. W. C. Shannon in Central America in connection with the survey of the Intercontinental Railway Commission has been published by JOHN DONNELL SMITH (Intercont. Railway Com. 1 : part 2. appendix 3. pp. 1–24. 1898. Washington.)— J. M. C.

MR. V. H. BLACKMAN, in his study of *Pinus sylvestris*[10] has made an important contribution to our knowledge of the subject of fertilization. Beginning with the formation of the ventral canal cell, the processes are traced with considerable detail up to the early stages in the formation of the sporophyte. During the great increase in size which the oosphere nucleus undergoes previous to fertilization, it becomes filled with a metaplasmic substance, at first granular, but in later stages taking the form of an elaborate reticulum, which might easily be mistaken for chromatin. The true chromatin, however, consists of a few small, rod-shaped masses.

The entire contents of the end of the pollen tube pass into the oosphere. The four nuclei are plainly visible as they enter the egg, but it is impossible to distinguish the stalk nucleus from the tube nucleus. As the sex nuclei come into contact, they are seen to contain numerous kinoplasmic threads which the writer regards as the beginning of the first segmentation spindle. The two groups of chromosomes, belonging respectively to the male and female nuclei, can be distinguished after the nuclear fusion is complete, and even after the first segmentation spindle is nearly formed ; in fact, the chromosomes were observed to undergo longitudinal splitting while the two groups were still distinct. According to all previous accounts of fertilization, the fusion nucleus enters a resting stage before segmentation begins. Since this paper was written Berlese has given a similar account of Peronospora.

The structure of the cytoplasm of the egg and the development and fate of achromatic figure, led to the conclusion that there is no specific kinoplasmic or archoplasmic substance, but that the fibers result from a rearrangement of the ordinary cytoplasmic reticulum.

[10] On the cytological features of fertilization and related phenomena in Pinus sylvestris. Phil. Trans. Royal Soc. London **190**: 395–426. 1898.

Blackman was not able to confirm Dixon's observations on the number of chromosomes. Dixon reported eight chromosomes in the nuclei of young embryo-sacs, eight in the nucleus of the oosphere, usually twelve but sometimes eight or twenty-four in the nuclei of the cells sheathing the oosphere. Dixon was not able to make a direct count of the chromosomes in the oosphere nucleus, but inferred the number from counting bodies in the nucleus of the ventral canal cell, which may have been disorganized chromatin and not normal chromosomes. Blackman's work, which was much more extensive, shows the number of chromosomes in the various nuclei to be as follows: In the egg, twelve; in pollen mother cells, twelve; nuclei of the female gametophyte, twelve; first division after fertilization, twenty-four; later divisions, over twenty-one and presumably twenty-four.

On account of recent work on Gingko, Cycas, and Zamia, a careful search was made for traces of cilia, blepharoplasts and centrosomes, but no such structures could be found, and the evidence furnished by Pinus was believed to bear out the conclusions of the various writers of the Bonn school against the presence of centrospheres in plants higher than mosses. — CHARLES J. CHAMBERLAIN.

PROFESSOR W. F. GANONG has published in the *Annals of Botany* (**12**: 423–474. 1898) further results of his investigation of the Cactaceæ, giving an account of the comparative morphology of the embryos and seedlings. The group is so modern and so plastic that the author anticipates that the phylogeny of its genera and species may be discovered with remarkable completeness.

As a result of the numerous germination experiments, some interesting conclusions are reached. Beginning with Pereskia, and passing by way of Cereus and Echinocactus to Mamillaria, the author calls attention to a progressive condensation in bulk of the germinated embryos, and consequent diminution of surface brought about by the increasing approach to a spherical form of the hypocotyl and diminution of the cotyledons. This progressive condensation of the embryos runs parallel with the condensation in the adults, but lags behind it, so that adult and embryo do not always correspond. The explanation suggested is that as the adult acquires a certain adaptive character, and it becomes more fixed and intensified, it tends to work back into earlier and earlier stages in the ontogeny of the successive individuals, until it finally reaches the embryo.

A phylogeny of the genera is constructed, based upon these recent observations, together with previously recorded facts. Neglecting the numerous genera which are not represented in our flora, and which for the most part are lines of secondary importance, the main points of the proposed phylogeny are as follows: Pereskia is regarded as nearest to the original stem-form of the family, and the earliest derived line was Opuntia. From the primitive

Opuntia forms the columnar Cereus line was derived, with its numerous generic branches and diverse habits. Low down upon the columnar Cereus line the Echinocactus line branched out, which gave rise later to Mamillaria, and still later to Anhalonium. — J. M. C.

A REDUCTION DIVISION of the chromosomes (in Weissmann's sense) is supposed by most botanists not to occur in plants. Guignard, Strasburger,[11] Sargant, Mottier, and many others find a longitudinal division of the chromosomes, and, consequently, only a numerical reduction. Schaffner finds a transverse division, and, consequently, a qualitative division (reduction division) in the first division in the embryo-sac of *Lilium;* Belajeff believes that a reduction division takes place in the second division of pollen mother cells; Calkins finds a reduction division in the second division of the spore mother cells of ferns.

A recent paper by W. C. Stevens[12] deals with the chromosome problem in ferns. *Scolopendrium vulgare, Cystopteris fragilis* ,and *Pteris aquilina* were investigated. The writer's summary is about as follows: In the first division of the spore mother cell the spirem thread splits longitudinally and then segments into one half the usual number of chromosomes. The daughter chromosomes are short and thick, and in their form resemble tetrads, but there is no transverse division. The daughter chromosomes begin to separate sometimes at the ends and sometimes in the middle, thus forming double rods or ring-shaped chromosomes. In the daughter nuclei the chromosomes unite into a single nuclear thread. In the second division this thread splits longitudinally and segments transversely, as in the first division. It follows that there is merely a reduction in the number of chromosomes, and not a reduction division. Calkins's figures lack important stages and do not prove a reduction division. A thorough search failed to reveal centrosomes or multipolar spindles. — CHARLES J. CHAMBERLAIN.

FORESTRY IN MINNESOTA, by Professor Samuel B. Green, published by the Minnesota Forestry Association, has been recently issued. It is neatly bound and well illustrated, and contains a good glossary and index, small details that greatly enhance the value of a most useful book. Professor Green has here brought together his class lectures, and they show him to be a thoroughly practical instructor. The little book contains just what the intending planter and the forest land owner need to know. The theory of tree growth is sketched, but the book is full of good practical suggestions on

[11] Strasburger and Mottier reported a transverse division in pollen mother-cells, but almost immediately acknowledged that their conclusion needed revision. BOT. GAZ. **26**: 220–221. 1898.

[12] Ueber Chromosomentheilung bei der Sporenbildung der Farne. Ber. d. deutsch. bot. Gesell. **16**: 261–265. 1898.

such useful and unfamiliar facts as the time of seeding, the treatment of forest tree seeds, the management of the forest nursery, planting, pruning, forest management, etc. With these, which are evidently based on experience, are full descriptions of the trees of Minnesota. It will prove valuable far beyond the limits of Minnesota. — CHARLES A. KEFFER.

THE WORK of Rimbach on geophilous plants has been previously alluded to.[13] He has recently published a contribution on the growth of rhizomes in depth.[14] Rhizomes have a so-called normal depth, varying with the species. Rimbach's experiments show that a removal of the soil from over a rhizome causes a downward growth, while a deep burial causes upward growth. These results are commonly brought about by a change in the direction of the rhizome axis, though sometimes by root contraction. Since these changes do not take place until some organ of the plant reaches the surface, the author thinks that they are caused by a greater or less need for structural materials on the part of the plant. — H. C. COWLES.

E. OVERTON makes a preliminary announcement[15] of a forthcoming paper on some experimental work on autumnal coloration. This much-vexed subject has long needed careful physiological investigation. He thinks that the red coloring matters of plants are probably glucosides, and in most cases unions of tannin compounds with sugar. The chief physical factors involved are sunshine, which augments sugar production, and low temperature, which prevents the conversion of sugar into starch. The replacement of starch by sugar in autumn and winter leaves had previously been shown by Lidforss.[16] Overton found that red tints could be produced in many leaves at any season by feeding them with glucose. — H. C. COWLES.

DR. GEORGE BITTER[17] has made some extended observations on the contact relationship of growing crustose and foliose lichens. The relationship is are said to be mostly of a saprophytic nature. In some instances contact lines vanish entirely, as when different individuals of *Variolaria globulifera* meet. Growth contact of different species may result in a complete or partial destruction of the less resisting species. In some instances the contact phenomena partake of the nature of parasitism (antagonistic symbiosis). The view is expressed that lichens take but comparatively little nourishment from the substratum. The principal function of the substratum seems to be that

[13] BOT. GAZ. **23**: 478. 1897.

[14] Beiträge zur wiss. Bot. **3**: 177–204. 1898.

[15] Nature **59**: 296. Jan. 1899.

[16] Bot. Cent. **68**: 33–44. 1896.

[17] Ueber das Verhalten der Krustenflechten beim Zusammentreffen ihrer Ränder. Jahrb. f. wiss. Bot. **33**: 47–127. *figs. 1–14.* 1898.

of a support. The author also refers to several fungi which are not generally recognized as lichens, namely, *Karschia* (*Buellia*) *scabrosa* and *Lecidea intumescens*. — A. SCHNEIDER.

IN A review of recent researches on the spermatozoids, Zacharias expresses himself thus on the centrosome question :[18]

"However, on an unprejudiced consideration of the literature involved, one may consider it not impossible that, on renewed search, the centrosomes will finally be again discovered where, for the present, they have been missed."— C. R. B.

DR. H. VON SCHRENK has been studying the mode of dissemination of *Usnea barbata*,[19] and finds that the wind is the chief agent of transfer. The long strands are broken and carried from tree to tree, and owing to hydroscopic movements the transported strands may soon become entangled with the new host. A similar study of *Ramalina reticulata*, by Peirce, was published in the BOTANICAL GAZETTE (**25** : 404. 1898).— J. M. C.

[18] Bot. Zeit. **57**[2] : 6. 1899.

[19] Trans. Acad. Sci. St. Louis **8** : 189–198. 1898.

NEWS.

MR. J. W. BLANKINSHIP has been appointed professor of botany in the Agricultural College of Montana.

DR. DOMENICO SACCARDO, assistant in botany in the university of Bologna, has been advanced to the professorship there.

DR. JOHANNES BEHRENS, bacteriologist, of Carlsruhe, has been appointed to a position under the Imperial Sanitary Bureau at Berlin.

THE BERLIN ACADEMY OF SCIENCES has made a grant of 2400 marks toward the expenses of a botanical expedition to Java by Dr. Paul Knuth.—*Science.*

DR. E. B. COPELAND has been appointed professor of biology in the State Normal School at Chico, California, and began his duties there about February first.

COHN'S *Beiträge zur Biologie der Pflanzen* is to be continued under the direction of Professor Dr. Oscar Brefeld, the successor of Cohn at the University of Breslau. The first part of the eighth volume has recently been published.

A PORTRAIT of the late Professor Teodoro Caruel, for twenty-two years the director of the *Nuovo Giornale Botanico Italiano*, forms the frontispiece of the sixth volume of that journal. In the *Bulletino della Societa Botanica Italiana* **1898**: 264 a list of the writings of this eminent botanist is given. The titles number 144.

THE FOURTH annual meeting of the Vermont Botanical Club was held on Friday and Saturday, January 27 and 28, 1899, in Williams Science Hall, of the University of Vermont, at Burlington. The program included a large number of papers, mostly relating to the Vermont flora. The Club seems to be vigorous, enrolling almost 100 members.

THE PUBLISHER of *American Gardening* announces March 1 an offer of three prizes of $75, $50, and $25 respectively, for the best papers on hybridization, of not less than 1000 nor more than 5000 words, to be presented before April 15, 1899. The brevity of both time and space allotted make practically impossible any thorough discussion of this large subject.

ON THE OCCASION of the retirement of Mr. J. G. Baker from the post of curator of the herbarium at Kew, his old colleagues, the members of the

staff, presented him with an address expressive of their affectionate regret. A representation of the elegant bromeliad called *Bakeria tillandsioides*, drawn by Miss Smith, the botanical artist, served to frame the address.—*Gardeners' Chronicle* III. **25**: 74.

A FIRE which broke out in the physical laboratory on the night of December 25 destroyed the buildings of the University of Geneva, and with them botanical collections of great value. The destruction involved the large Delessert herbarium, Professor R. Chodat's personal herbarium and about 200 drawings, representing the labor of ten years, Huber's Mediterranean plants, and various collections loaned by other herbaria for study. Such losses are irreparable.

AT THE MEETING of the Academy of Science of St. Louis on January 9, 1899, Mr. Hermann von Schrenk presented informally the results of a study of a sclerotium disease of beech roots which he had observed in southeastern New York during the past summer. The sclerotia, which were formed by the webbing together of rootlets by sterile mycelial threads, have apparently no connection with the mycorhiza of the beech. Mr. von Schrenk's remarks were illustrated by drawings and specimens.—WILLIAM TRELEASE.

THE UNIVERSITY OF TEXAS has established a distinct department of botany, which will begin its separate existence with the next college year. The matter is of special interest since, so far as is known at this writing, this is the first independent department of botany in connection with any southern university. Dr. Wm. L. Bray, who recently received his doctor's degree from the University of Chicago, has been in charge of the botanical work at the University for two years, and will be in charge of the new department.

ON FEBRUARY ninth, a fire in Maxcy House, a dormitory of Brown University, caused considerable damage to the botanical department which occupied quarters in the basement. Fortunately the loss was not so serious as was reported in the daily papers. The herbarium and outfit of apparatus are practically uninjured. Many books and charts are damaged by water, and the economic collections, stored above, were entirely destroyed. We hope that the final result will be to the betterment of the department and that the interruption of its work will be brief.

AT THE MEETING of the Academy of Science of St. Louis, on January 23, 1899, a paper by Professor A. S. Hitchcock, entitled "Studies on subterranean organs, Part I, Compositæ of the vicinity of Manhattan, Kansas," dealing with the structure of a number of rootstocks with reference to their environment, was presented in abstract. Mr. C. H. Thompson also spoke of some plants whose flowers originate endogenously. He mentioned several species of Rhipsalis in which the much reduced leaves grow on trian-

gular or cylindrical very succulent stems, their axillary buds originating deep down in the soft tissue and sometimes having a passage-way extending toward the surface. In two species of Rhipsalis (*R. paradoxa* and *R. floccosa*) there is no such passage-way, and the bud, in developing, breaks through the epidermis. In *Rhipsalis glaucosa*, a number of accessory abortive flowers were found. *Cuscuta glomerata* was mentioned as the only other plant in which, so far as the speaker knew, subepidermal flowers occur.—WILLIAM TRELEASE.

THE BIOLOGICAL LABORATORY of the Brooklyn Institute of Arts and Sciences, located at Cold Spring Harbor, Long Island, will begin its tenth season on Wednesday, July 5, under the direction of Dr. C. B. Davenport, of Harvard University, and regular class work will continue for six weeks. The laboratory will be open for work from July 3 until August 31. Special students may make arrangements for using the laboratory from the middle of June until the middle of September, or later, if desirous of doing so. The general botanical work will be in the charge of Dr. D. S. Johnson, of Johns Hopkins University, and the bacteriology in charge of Mr. N. S. Davis, of Bucknell University.

THE UNIVERSITY OF MINNESOTA is about to organize a new herbarium classified upon ecological lines. This will be supplementary to the large taxonomic collections already displayed. The ordinary sheets and folio covers will be retained, but plants will be segregated upon their ecological characters. Thus, under the general divisions as blocked out in Schimper's new work, *Pflanzengeographie*, a minute subclassification has been devised — for example, under xerophytes, succulents; under succulents, leaf-succulents; under leaf-succulents, various edaphic groups — rock-succulents, salt-succulents, desert-succulents, etc. — and under these the geographical groups, American, European, Asiatic, etc., according to the geographical classification of Schimper, Drude, and Grisebach, as may be found convenient. A similar classification applies to the other ecological groups. It is believed that this organization of a second herbarium containing duplicates of the taxonomic collection and thoroughly adaptational in its classification will prove of great advantage as an aid to instruction.

THE ANNUAL REPORT of the director of the Field Columbian Museum for 1897–8 shows that the department of botany has been enriched by a large amount of material. "The most important collection acquired during the year was the complete herbarium of the late Mr. M. S. Bebb, including his library, letters, and drawings. Through this collection and that of Dr. Schott, obtained the previous year, the herbarium of the museum has been in many important collections projected backward to the middle of the present century. Locally, the herbarium of Mr. Bebb is of great value, as it

represents much of the flora of the western states and about all that of Illinois. The collection of willows is very complete, and, in connection with his notes, drawings, and communicated types, is acknowledged to be the very best. Another collection of Yucatan plants has been received from Dr. Gaumer, consisting of many thousand representatives from old and new localities on the peninsula, which collections will form the basis of a fourth contribution to the flora of that region, and will provide a large amount of valuable duplicate material for exchange. In addition to the above more notable accessions, the following sets have been acquired during the year: Pringle and Palmer's new Mexican material; Anthony's Insular Mexican collection; Lumholtz's Mexican plants; Peary Relief Expedition plants of Labrador and Greenland; Schlechter's African centuries; Heller's Sandwich islands, New Mexican, and Texan plants; Millspaugh's West Virginian and New York plants; Pollock's West Virginian species; Lorenz and Hieronymus' Argentine flora; Allen's plants of the Cascade mountains; Dr. Edward Palmer's Florida collection of 1874; Franchsschi's Grecian plants; Lansing's centuries of the plants of the Lake Michigan basin; and the Curator's plants of Mackinac island."